

SONY / Apple

CD-R Command Set Proposal

for MMC

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1. Introduction

This document specifies SCSI command set for CD-R drive. This SCSI command set is proposed to the ANSI SCSI-3 MMC committee. New SCSI commands, not specified in the SCSI-2 document, are added to support advance features in CD-R drive. Some of the SCSI-2 Commands are also described in this document to clear its operation for CD-R media. All commands supported are described in alphabetic order in this document.

2. Ready Condition/Not Ready Condition

The Ready Condition occurs after a caddy is inserted and the disc is recognized.

A not Ready Condition occurs for the following reasons:

- 1) There is no caddy inserted.
- 2) The drive is unable to load or unload the caddy.
- 3) The drive is unable to recognize a disc.
- 4) The target cannot select drive. (This can only occur if the target was previously able to select the drive).

A CHECK CONDITION status will be returned for the drive not Ready condition only for commands that require or imply a disc access. The following commands will not return a CHECK CONDITION status for the not Ready condition. The value in parenthesis is the command code.

- | | |
|--------------------------|---|
| 1) REQUEST SENSE (03h) | 7) STOP UNIT with LoEj bit set to one (1Bh) |
| 2) INQUIRY (12h) | 8) ALLOW MEDIUM REMOVAL (1Eh) |
| 3) MODE SELECT (6) (15h) | 9) READ BUFFER (3Ch) |
| 4) RESERVE (16h) | 10) WRITE BUFFER (3Bh) |
| 5) RELEASE (17h) | 11) READ BUFFER CAPACITY (5Ch) |
| 6) MODE SENSE (6) (1A) | |

The following commands will return a CHECK CONDITION status for the not Ready condition. The value in parenthesis is the command code.

- | | |
|--|-----------------------------|
| 1) TEST UNIT READY (00h) | 19) PAUSE/RESUME (4Bh) |
| 2) REZERO UNIT (01h) | 20) PLAY AUDIO (12) (A5h) |
| 3) READ (6) (08h) | 21) READ (12) (A8h) |
| 4) WRITE (6) (0Ah) | 22) AUDIO SCAN (BAh) |
| 5) SEEK (6) (0Bh) | 23) READ CD-DA (D8h) |
| 6) START UNIT with Start bit set (1Bh) | 24) READ CD-DA MSF (D9h) |
| 7) RECEIVE DIAGNOSTIC RESULTS (1Ch) | 25) READ ALL SUBCODES (DFh) |
| 8) SEND DIAGNOSTIC (1Dh) | 26) WRITE START (50h) |
| 9) PREVENT MEDIUM REMOVAL (1Eh) | 27) WRITE CONTINUE (51h) |
| 10) READ CD-ROM CAPACITY (25h) | 28) DISCONTINUE (52h) |
| 11) READ (10) (28h) | 29) READ MASTER CUE (59h) |
| 12) WRITE (10) (2Ah) | 30) CLOSE TRACK (5Ah) |
| 13) SEEK (10) (2Bh) | 31) FINALIZE (5Bh) |
| 14) READ SUB-CHANNEL (42h) | 32) FLUSH (5Dh) |
| 15) READ TOC (43h) | 33) RESERVE TRACK (53h) |
| 16) PLAY AUDIO (10) (45h) | 34) WRITE TRACK (5Eh) |
| 17) PLAY AUDIO MSF (47h) | 35) RECOVER TRACK (5Fh) |
| 18) PLAY AUDIO TRACK/INDEX (48h) | |

3. Audio Playback Implementation Rules

The rules for audio playback operations are as follows:

- 1) The audio addresses will be valid until a reset condition, a medium change occurs or until another command is received with a new audio address.
- 2) The audio addresses must be within an audio track. If the audio address is not within an audio track, the command will be terminated with a CHECK CONDITION status. The sense key will be set to ILLEGAL REQUEST and the additional sense code set to ILLEGAL MODE FOR THIS TRACK(64h).
- 3) If Lead out track, unwritten area or a change in bit two of the control field is detected, the playback operation will be terminated with a CHECK CONDITION status. The sense key will be set to ILLEGAL REQUEST and the additional sense code set to END OF USER AREA ENCOUNTERED ON THIS TRACK(63h).

If any of the following conditions occur and the drive has not detected the ending audio address, audio play operation will continue on the next track.

- a) an index equal zero is detected (i.e. pre-gap detected).
- b) a track number change is detected.

The ending audio address may be set while audio play is in progress. If the ending address requested is not greater than the current address the audio play operation will stop and the drive will enter the hold track state.

- 4) The audio play operation will not be interrupted by the following commands received by the target.

TEST UNIT READY	READ CD-ROM CAPACITY
REQUEST SENSE	WRITE BUFFER
INQUIRY	READ BUFFER
RESERVE	READ TOC (43h)
RELEASE	READ SUB-CHANNEL (42h) (with Sub Channel Data Format field 01h)
MODE SELECT(6)	RECEIVE DIAGNOSTIC RESULTS
MODE SENSE(6)	READ BUFFER CAPACITY

4. CD-R Devices

4.1 CD-R Model

This section talks about the basic concept of Orange Book to support full feature of CD-R units.

4.1.1. CD-R Data Organization

4.1.1.1. Disc Styles

CD and CD-R discs include interrupted disc are divided into the following two styles:

- * Compatible Disc to Yellow Book and Red Book
- * Interrupted Recording Disc follow Orange Book

The above styles are defined as Disc Styles.

4.1.1.2. Compatible Disc to Yellow Book and Red Book

This disc follows CD standards (Yellow Book and Red Book), and is belonging to which one of the following two types.

- * Conventional CD/CD-ROM Disc
- * Uninterrupted Recorded CD-R Disc

Uninterrupted Recorded CD-R Disc is a disc written all at once using CD Recorder. This write method is called Disc at Once Recording. Any additional data cannot be written in the disc written by this write method.

4.1.1.3. Interrupted Recording Disc follow Orange Book

This disc follows Orange Book Part II , and is Interrupted Recorded CD-R disc. Additional data can be written in the disc.

The disc is which one of Audio Disc or Data Disc finally. Each disc has the following feature.

Audio Disc:

- * A disc does not include data track
- * Skip Function is usable
- * Single-session only
- * A track cannot be reserved
- * Track at Once Recording only

Data Disc:

- * A disc includes data track in every session
- * Skip Function is not usable
- * Single-session or Multi-session
- * A track can be reserved
- * Track at Once Recording or Packet Recording

Disc Areas

The disc has the following five areas:

1) Power Calibration Area (PCA)

PCA area is for optimizing write power before writing.

- 2) Program Memory Area (PMA)
The Start and End address of written track, Disc Identification and Disc Type are written in PMA.
Every time a disc is taken out from a Recorder, PMA is revised the latest contents.
After writing the last track of a disc, Table of Contents (TOC) data is generated on the all data of PMA and is written in Lead In area.
At this time writing in Lead Out area is performed. This is called 'finalize'.
- 3) Lead In Area
TOC data is written in Lead in Area.
- 4) Program Area
User data is written in Program Area. CD-R recorder writes user data in a track of this area.
- 5) Lead Out Area
Lead Out Area is gird area for Conventional CD. Writing in Lead Out Area is performed when finalize.

Three methods of Interrupted Recording

Track at Once Recording

A track is written all at once and Addressing Method-1 is used for this track. Audio track must be written by this method.

Fixed Packet Recording

A few packets can be written in a track. Every packet is written at one writing. The length of every packet in the track must be equal. Addressing Method-2 is used for this track. This method is available for Data track only.

Variable Packet Recording

A few packets can be written in a track. Every packet is written at one writing. The length of every packet in the track is not necessary equal. Addressing Method-1 is used for this track. This method is available for Data track only.

Data Linking Rules

In Data Track, one set of recorded Link, Run-in, User Data and Run-out blocks is called a Packet. The number of User Data blocks in a Packet is called the Packet Size. The writing can be interrupted at Link block. Mode Byte in Header of User Data Blocks, Run-in Blocks (#1-#4) , Link Block and Run-out Blocks (#1-#2) each is defined as follows

Bit 7	Bit 6	Bit 5	Block Type
0	0	0	User Data Block
0	0	1	Fourth Run-in
0	1	0	Third Run-in
0	1	1	Second Run-in
1	0	0	First Run-in
1	0	1	Link
1	1	0	Second Run-out
1	1	1	First Run-out

Pre-gap

All data tracks must have pre-gap. A starting address of the track follows last block of the pre-gap. If the first user data of a data track follows Link Block and four Run-in Blocks, the Pre-gap must include those blocks. At this time, the starting address of the track is located at the head of first user data of the track.

Track Descriptor Block

Track Descriptor Block is belonging to second part of Pre-gap. Track Descriptor Block has the following contents.

- *Pre-gap Length (Second Part)
- *Track Number
- *Write Method
- *Packet Size of Fixed Packet

Multi-Session Disc

Multi-Session Disc consists of PCA, PMA and more than one session. Every session has Lead In Area, Program Area and Lead Out Area.

Addressing Method

The Addressing Method gives the relation between the Logical Block Numbering and the Block Header Address numbering. There are two methods:

Method 1

Logical Block Number (LBN) = (((MIN*60)+SEC)*75+FRAMS)-150

Method 2

The LBNs upto and including the first User Data Block in a track are calculated by:

$LBN = (((MIN*60)+SEC)*75+FRAMS)-150$

All the following LBNs are calculated by counting all User Data Blocks in the track. This means that all Run-in blocks, Run-out blocks and Link blocks are excluded.

Reserved Track

Reserved Track is data track in which the data is not yet recorded completely, but the Start and the Stop time of the track is recorded in the PMA. Before the disc or the session is finalized, all the Reserved Tracks in the finalized part of the disc must be recorded.

Skip Function

Skip Item is written in PMA in order to skip an entire track or a part of a recorded track (a time interval) during play back of the disc. Skip Function is available for Audio Disc only.

4.1.2. CD-R Recording Rules

4.1.2.1. General Recording Rules

Interrupted Recording Disc follows the following rules.

If there is more than one session on a disc, all tracks included all sessions except last session must be Complete Track.

The track numbers of all Incomplete, Empty Reserved, Partly Recorded Reserved and Complete Track on a disc must be contiguous and increment by one from inside to outside of the disc.

Additional recording in the track must start just after the last recording in the track.

4.1.2.2. Definition of track status and state transition

Track status of a disc follows Orange Book is divided into the following 7 status.

- Complete Track
- Empty Reserved Track
- Partly Recorded Reserved Track
- Incomplete Track
- Invisible Track
- during Track at Once Recording for Invisible Track
- during Track at Once Recording for Empty Reserved Track

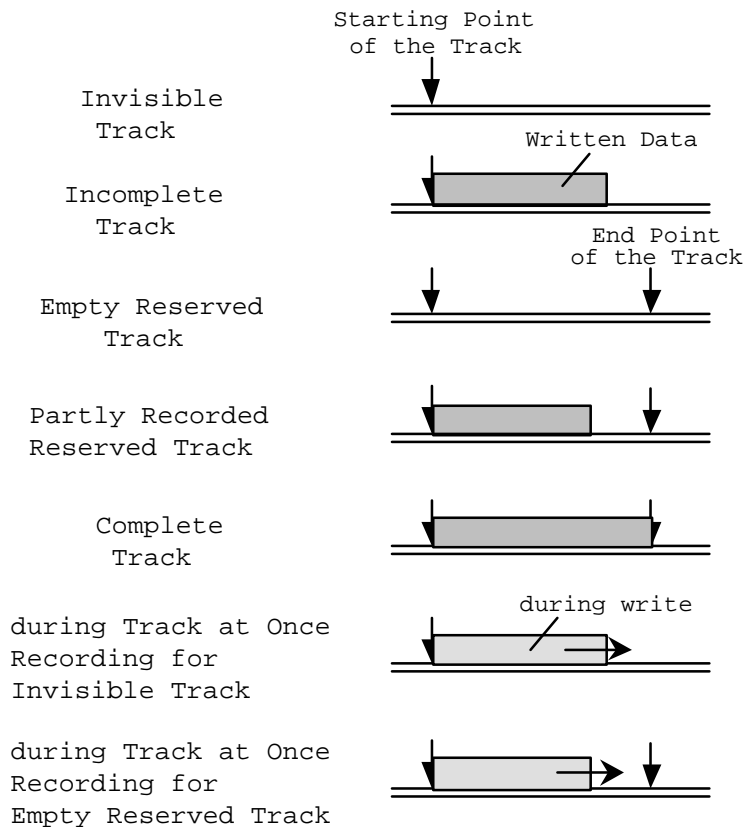


Figure 4-1 Status of a track

4.1.2.2.1. Definition of Track status

Complete Track

Complete Track is a track that all area from Start time to Stop time of the track are written. The Start time and Stop time are determined by TOC item in PMA.

Capacity of Blank Area of the track is always zero because the track has no writable area.

This track status is not turned to other status.

Empty Reserved Track

A track that Start time and Stop time are written in PMA and that is not written at all is called Empty Reserved Track. Empty Reserved Track is always Data Track.

Partly Recorded Reserved Track

A track that Start time and Stop time are written in PMA and that is written partly is called Partly Recorded Reserved Track. Partly Recorded Reserved Track is always Data Track specified as Packet Recording.

Incomplete Track

A track that Start time and Stop time are not written in PMA and that is written partly is called Incomplete Track. Incomplete Track is always Data Track specified as Packet Recording.

Invisible Track

Invisible Track is a track which can be written and is not written at all on the disc currently. Invisible Track is defined only the following two cases.

Blank Disc

If a disc is Blank disc, the unwritten first track is assumed as Invisible Track. In this case, the track number of Invisible Track is changeable and specified in First Track Number field in Disc Information Page.

Not Blank Disc

If a disc is not Blank disc and a last track already written on a disc is Complete Track or Reserved Track and last session is not finalized, Invisible Track is defined. In this case, starting address of Invisible Track is placed at next to Ending Point of the last track. The track number of Invisible Track is the number added 1 to the track number of the last track.

If a disc is not Blank disc and a last session is finalized with Allowed Next Session, Invisible Track is defined. In this case, starting address of Invisible Track is placed at next to Ending Point of the Lead-in track of next session.

If the last track is Incomplete Track, Invisible Track is never defined.

during Track at Once Recording for Invisible Track

"During Track at Once Recording for Invisible Track" is one of track status during Track at Once Recording. If the initiator issues the WRITE TRACK command to Invisible Track, the status of track goes to this status.

The initiator continues to issue the WRITE CONTINUE command and to add data to the buffer. At the same time, data in the buffer is written in order from head on a disc. To keep this status, the initiator must issue the WRITE CONTINUE command constantly so that buffer is always enough.

The length of the track in this status is not fixed.

If the initiator issues the CLOSE TRACK command in this status, this status ends. Then writing of the track completes and the length of track is fixed.

This status ends in the following cases.

- 1) issue of the CLOSE TRACK command
- 2) no writable area for the track by continuing to issue the WRITE CONTINUE command(Track Full)

during Track at Once Recording for Empty Reserved Track

"During Track at Once Recording for Empty Reserved Track" is one of track status during Track at Once Recording. If the initiator issues the WRITE TRACK command to Empty Reserved Track, the status of track goes to this status.

The initiator continues to issue the WRITE CONTINUE command and to add data to the buffer. At the same time, data in the buffer is written in order from head on a disc. To keep this status, the initiator must issue the WRITE CONTINUE command constantly so that buffer is always enough.

The length of the track in this status is fixed in advance.

This status ends the following cases.

- 1) issue of the CLOSE TRACK command with Padding=1
- 2) no writable area for the track by continuing to issue the WRITE CONTINUE command(Track Full)

4.1.2.2.2. State transition of Track

State Transition Table of Status and Event is as follows:

- T1. Invisible Track
- T2. Incomplete Track
- T3. Empty Reserved Track
- T4. Partly Recorded Reserved Track
- T5. during Track at Once Recording for Invisible Track
- T6. during Track at Once Recording for Empty Reserved Track
- T7. Complete Track

This is State transition from T1 to T7.

Table 4-1 State Transition-1

Event	WRITE Capa > 0	WRITE Capa == 0	RESERVE TRACK Capa > 0	RESERVE TRACK Capa == 0	CLOSE TRACK No Pad	CLOSE TRACK With Pad
From						
T1. Invisible Track	T2	T2	T3/T4	x	x	x
T2. Incomplete Track	T2	-	T4	T7	T7	T7
T3. Empty Reserved Track	T4	T7	x	x	x	x
T4. Partly Recorded Reserved Track	T4	T7	x	x	x	T7
T5. during Track at Once Recording for Invisible Track	x	x	x	x	T7	T7
T6. during Track at Once Recording for Empty Reserved Track	x	x	x	x	x	T7
T7. Complete Track	x	x	x	x	x	x

Table 4-2 State Transition-2

Event	WRITE TRACK	WRITE CONTI. Capa > 0	WRITE CONTI. Capa == 0	FINALIZE No Pad	FINALIZE With Pad
From					
T1. Invisible Track	T5	-	-	*	*
T2. Incomplete Track	x	-	-	T7	T7
T3. Empty Reserved Track	T6	-	-	x	x
T4. Partly Recorded Reserved Track	x	-	-	x	T7
T5. during Track at Once Recording for Invisible Track	x	T5	T7	T7	T7
T6. during Track at Once Recording for Empty Reserved Track	x	T6	T7	x	T7
T7. Complete Track	x	x	x	-	-

- * If Next Session of FINALIZE command is 01h, Invisible Track moves to next session. If Next Session of FINALIZE command is 00h, Invisible Track disappears.

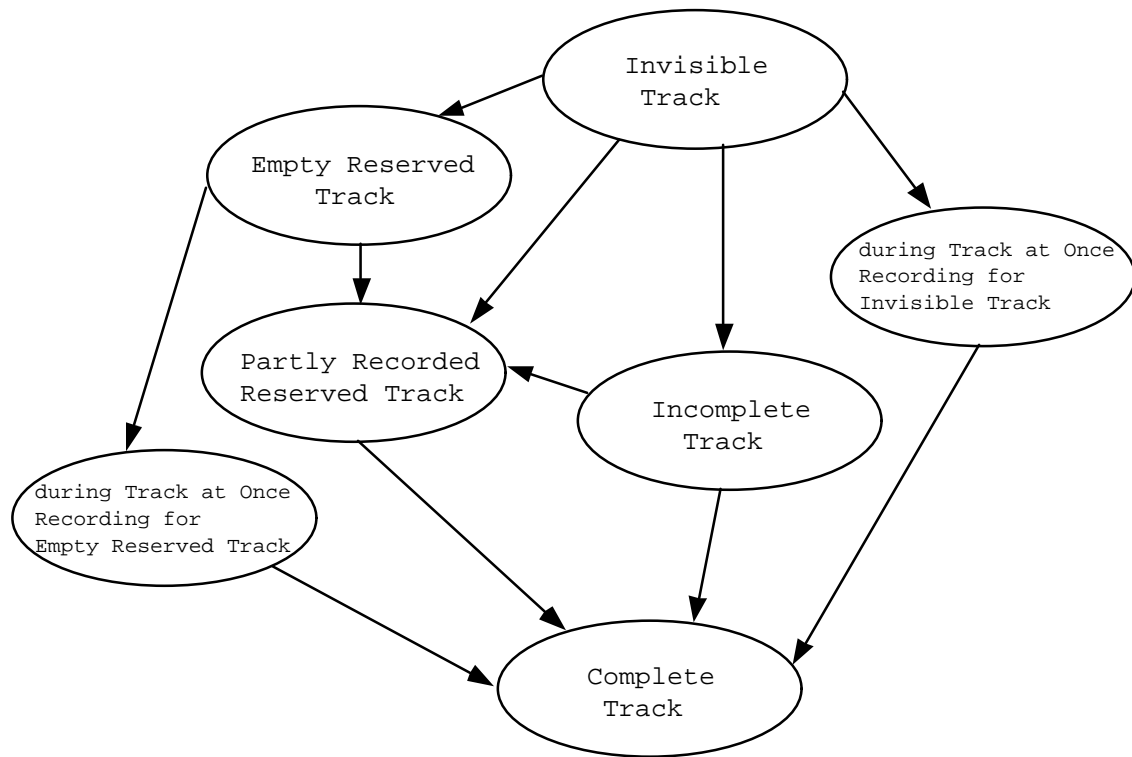


Figure 4-2 State Transition

4.1.2.3. Example of writing of CD-R disc

(1) Preparation before issue of the WRITE command

(1)-1 Reading current value of Disc Information Page and Track Information Page

The initiator reads Track Information Page of all tracks and Disc Information Page of a disc after the drive recognizes, in order to get the unwritten area and the current writing parameters.

The lists of fields of Track Information Page and Disc Information Page are as follows. For the details of each field, see 4.4.1.3 and 4.4.1.4 Mode pages.

The fields of Disc Information Page

D1	Disc Style
D2	Disc Type
D3	First Track Number
D4	Last Track Number
D5	Number of Sessions
D6	Disc Application Code
D7	Last Possible Start Time of Lead Out
D8	Disc Status
D9	Number of Valid NRA
D10	Track Number of Track Information Page
D11	Post-Gap
D12	Disc Identification Code

The fields of Track Information Page

T1	Track Number
T2	Data Form
T3	Write Method
T4	Starting LBA of the Track
T5	Next Recordable Address
T6	Track Status
T7	Session Number
T8	Capacity of Blank Area
T9	Fixed Packet Size
T10,11,12	Starting M,S,F
T13,14,15	Ending M,S,F
T16,17,18	Recordable Point M,S,F

If more than one tracks are on a disc, information of only one track specified by Track Number field (T1) can be got or set in Track Information Page.

To get the information of other track, the initiator rewrites Track Number of Track Information Page (D10) in Disc Information Page by the MODE SELECT command and reads the Track Information Page by the MODE SENSE command.

To get the information of all tracks, the initiator performs the above procedure to all tracks. A range of track number specified by Track Number of Track Information field must be equal to or larger than First Track Number (D3), and is equal to or smaller than Last Track Number (D4) of Disc Information Page.

(1)-2 Reading changeable value of Disc Information Page and Track Information Page

In case of changing a value in fields of Disc Information Page or Track Information Page, MODE SENSE command with PC="Changeable Value" is issued in order to check the field is whether changeable or not.

(1)-3 Rewriting Disc Information Page and Track Information Page

If a field is changeable, the current value of the field can be rewritten to new value by the MODE SELECT command.

(2) Issue WRITE Command and writing user data

(2)-1 Specifying writing address by LBA field of the WRITE Command

A address specified by LBA field of the WRITE command must be equal to one of NRA (Next Recordable Address) on a disc.

If a disc has Reserved Track, the number of NRA in the disc is more than one. The number of NRA is indicated in Number of Valid NRA field in Disc Information Page.

The initiator gets all NRA and the track number of them by checking NRA field in Track Information Page of each track in descending order from Last Track Number.

If any NRA is not equal to LBA of the WRITE command, the WRITE command is terminated with the CHECK CONDITION status.

(2)-2 Writing Pre-gap with Track Descriptor Block

If a track with NRA specified by the WRITE command is Invisible Track or Empty Reserved Track, Pre-gap is written before writing of all packet.

(2)-3 Writing in case of Write Cache Disable

The initiator writes one Packet by one WRITE command. Transfer Length of the WRITE command must be equal to Packet length.

The Packet length must be smaller than buffer length of the drive. If the Packet is Fixed Packet, the Transfer Length must be equal to the value of Fixed Packet Size field in Track Information Page.

The drive writes all data specified by this command on a disc and then the GOOD status is returned.

4.2. Recommended Commands(in alphabetical order by op-code)

The following table lists the commands to support CD-R features in alphabetical order by op-code. Some of the general commands are also included as to support basic feature of CD-ROM Drive.

Table 4-3 Implemented Commands(in alphabetical order by op-code)

Command Name	Command Code	Type	Section
Group 0 command			
TEST UNIT READY	00h	M	n/a
REZERO UNIT	01h	M	n/a
REQUEST SENSE	03h	M	n/a
READ(6)	08h	M	4.3.1.3
WRITE(6)	0Ah	M	4.3.2.9
SEEK(6)	0Bh	M	n/a
INQUIRY	12h	M	4.3.1.1
MODE SELECT(6)	15h	M	4.3.1.2
RESERVE	16h	M	n/a
RELEASE	17h	M	n/a
MODE SENSE(6)	1Ah	M	n/a
START/STOP UNIT	1Bh	M	n/a
RECEIVE DIAGNOSTIC RESULT	1Ch	O	n/a
SEND DIAGNOSTIC	1Dh	M	n/a
PREVENT/ALLOW MEDIUM REMOVAL	1Eh	M	n/a
Group 1 Command			
READ CD-ROM CAPACITY	25h	M	4.3.1.4
READ(10)	28h	M	4.3.1.3
WRITE(10)	2Ah	M	4.3.2.9
SEEK(10)	2Bh	M	n/a
WRITE BUFFER	3Bh	O	n/a
READ BUFFER	3Ch	O	n/a
Group 2 Command			
READ SUB-CHANNEL	42h	O	n/a
READ TOC	43h	O	4.3.1.8
PLAY AUDIO(10)	45h	O	n/a
PLAY AUDIO MSF	47h	O	n/a
PLAY AUDIO TRACK/INDEX	48h	O	n/a
PAUSE/RESUME	4Bh	O	n/a
Group 5 Command			
PLAY AUDIO(12)	A5h	O	n/a
READ(12)	A8h	O	4.3.1.9
Group 6 Command			
READ CD-DA	D8h	O	4.3.1.7
READ CD-DA MSF	D9h	O	4.3.1.8
READ ALL SUBCODES	DFh	O	4.3.1.5

Command Name	Command Code	Type	Section
New Group 2 Command			
WRITE START	50h	O	4.3.2.11
WRITE CONTINUE	51h	M	4.3.2.10
DISCONTINUE	52h	O	4.3.2.2
READ MASTER CUE	59h	O	4.3.2.6
READ BUFFER CAPACITY	5Ch	O	4.3.2.5
CLOSE TRACK	5Ah	M	4.3.2.1
FINALIZE	5Bh	M	4.3.2.3
FLUSH	5Dh	O	4.3.2.4
RESERVE TRACK	53h	M	4.3.2.8
WRITE TRACK	5Eh	M	4.3.2.12
RECOVER TRACK	5Fh	O	4.3.2.7

M: Mandatory O: Optional V: Vendor Unique

4.3. Command Descriptions

4.3.1. CD-ROM Compatible Commands

The following table lists the commands implemented to support CD-ROM features. The special consideration to support CD-R device is described in following sections even though the command is general SCSI-2 command. This list is written by the alphabetical order. The command descriptions are in alphabetical order by command name.

Table 4-4 Implemented Commands

Command Name	Command Code	Type	Section
INQUIRY	12h	M	4.3.1.1
MODE SELECT (6)	15h	M	4.3.1.2
MODE SENSE (6)	1Ah	M	n/a
PAUSE/RESUME	4Bh	O	n/a
PLAY AUDIO (10)	45h	O	n/a
PLAY AUDIO (12)	A5h	O	n/a
PLAY AUDIO MSF	47h	O	n/a
PLAY AUDIO TRACK/INDEX	48h	O	n/a
PREVENT/ALLOW MEDIUM REMOVAL	1Eh	M	n/a
READ (6)	08h	M	4.3.1.3
READ (10)	28h	M	4.3.1.3
READ (12)	A8h	O	4.3.1.3
READ ALL SUBCODES	DFh	O	4.3.1.5
READ BUFFER	3Ch	O	n/a
READ CD-DA	D8h	O	4.3.1.7
READ CD-DA MSF	D9h	O	n/a
READ CD-ROM CAPACITY	25h	M	4.3.1.4
READ SUB-CHANNEL	42h	O	n/a
READ TOC	43h	O	4.3.1.8
RECEIVE DIAGNOSTIC RESULT	1Ch	O	n/a
RELEASE	17h	M	n/a
REQUEST SENSE	03h	M	n/a
RESERVE	16h	M	n/a
REZERO UNIT	01h	M	n/a
SEEK (6)	0Bh	M	n/a
SEEK (10)	2Bh	M	n/a
SEND DIAGNOSTIC	1Dh	M	n/a
START/STOP UNIT	1Bh	M	n/a
TEST UNIT READY	00h	M	n/a
WRITE BUFFER	3Bh	O	n/a

M: Mandatory O: Optional V: Vendor Unique

4.3.1.1. INQUIRY Command (12h)

The Peripheral Device Type code is set to 04h as WO device if the logical unit is present. If the logical unit is not present the peripheral device type code is set to 7Fh.

4.3.1.2. MODE SELECT(6) Command (15h)

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Operation Code (15h)							
1	Logical Unit Number			PF	Reserved			SP(0h)
2	Reserved							
3	Reserved							
4	Parameter List Length							
5	Control Byte							

The MODE SELECT(6) command provides a means for the initiator to specify medium, logical unit, or peripheral device parameters to the target. Initiators should issue MODE SENSE prior to MODE SELECT to determine supported pages, page lengths, and other parameters.

If an initiator sends a MODE SELECT command that changes any parameters that apply to other initiators, the target will generate a Unit Attention condition for all initiators except the one that issued the MODE SELECT command. The target will set the additional sense code to MODE PARAMETERS CHANGED(2Ah).

The target does not check the value of page format(PF) bit.

The Parameter List Length specifies the length in bytes of the MODE SELECT parameter list that will be transferred from the initiator to the target. A Parameter List Length of zero indicates that no data will be transferred. This condition will not be considered as an error. A Parameter List Length that results in the truncation of any descriptor, header, or page parameters will cause the target to terminate the command with CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to INVALID FIELD IN PARAMETER LIST(26h).

The MODE SELECT parameter list contains a four-byte header, followed by zero or one eight-byte block descriptor, followed by zero or more pages.

Mode Select Parameter List**Header**

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Reserved							
1	Medium Type (00h)							
2	Reserved							
3	Block Descriptor Length(00h or 08h)							

Block Descriptor

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Density Code (00h)							
1	Number of Blocks (MSB)							
2	Number of Blocks							
3	Number of Blocks (LSB)							
4	Reserved							
5	Block Length (MSB)							
6	Block Length							
7	Block Length (LSB)							

Page(s)

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0						
0	Reserved		Page Code											
1	Page-Specific Parameter Length													
2	Page-Specific Parameters													
n														

The Medium Type is set to zero to indicate the default.

The Block Descriptor Length field will be set to either 00h or 08h.

The Block Descriptor specifies the medium characteristics for the whole disc.

The Density Code is set to zero. This is the only density code acceptable to the target.

The Number of Blocks field is set zero. This indicates the whole disc has the block length specified.

The Block Length specifies the length in bytes of each logical block. The target will accept the block lengths of 512(200h), 1024(400h), 2048(800h), 2056(808h), 2336(920h), 2340(930h), 2352(930h), and 2646(A56h) for CD-ROM (mode 1 and mode 2), CD-XA and CD-I (mode 2 form 1 and mode 2 form 2) blocks. Any other value will be considered an error. The command will be terminated with a CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to INVALID FIELD IN PARAMETER LIST(26h). The block length is applicable to the whole disc except for playing audio tracks.

The following table listed the supported block length for various CD formats.

(Note: The Block Length field has no effect on CD-DA blocks. For reading CD-DA blocks over SCSI, the CD-DA block length is determined by the Sub Code field (byte10) in the Read CD-DA or Read CD-DA MSF command. CD-DA blocks can not be read by a normal Read(6), Read(10) or Read(12) command.)

Table 4-5 Block Length

	512	1024	2048	2056	2336	2340	2352	2368	2448	2646
CD-DA							xx	x	x	
CD-ROM										
Mode 1	x	x	xx		xx	xx	xx			x
Mode 2					xx	xx	xx			x
CD-ROM XA or CD-I										
Form 1	x	x	x	x	xx	xx	xx			x
Form 2					xx	xx	xx			x

x: Read only is possible. xx: Read and Write are possible.

CD-DA Data Format

- 1) 2352 bytes: Audio data(2352 bytes)
- 2) 2368 bytes: Audio data(2352 bytes) + Q-Subcode(16 bytes)
- 3) 2448 bytes: Audio data(2352 bytes) + All(P~W) Subcodes(96 bytes)

CD-ROM Mode 1 Data Format

- 1) 2048 bytes: User data(2048 bytes)
- 2) 2336 bytes: User data(2048 bytes) + EDC(4 bytes) + Zero(8 bytes) + ECC(276 bytes)
- 3) 2340 bytes: Header(4 bytes) + User data(2048 bytes) + EDC(4 bytes) + Zero(8 bytes) + ECC(276 bytes)
- 4) 2352 bytes: Sync(12 bytes) + Header(4 bytes) + User data(2048 bytes) + EDC(4 bytes) + Zero(8 bytes) + ECC(276 bytes)

CD-ROM Mode 2 Data Format

- 1) 2336 bytes: Mode 2 user data(2336 bytes)
- 2) 2340 bytes: Header(4 bytes) + Mode 2 user data(2336 bytes)
- 3) 2352 bytes: Sync(12 bytes) + Header(4 bytes) + Mode 2 user data(2336 bytes)

CD-ROM XA or CD-I Mode 2 Form 1 Data Format

- 1) 2048 bytes: User Data(2048 bytes)
- 2) 2056 bytes: Subheader(8 bytes) + User data(2048 bytes)
- 3) 2336 bytes: Subheader(8 bytes) + User data(2048 bytes) + EDC(4 bytes) + ECC(276 bytes)
- 4) 2340 bytes: Header(4 bytes) + Subheader(8 bytes) + User data(2048 bytes) + EDC(4 bytes) + ECC(276 bytes)
- 5) 2352 bytes: Sync(12 bytes) + Header(4 bytes) + Subheader(8 bytes) + User data(2048 bytes) + EDC(4 bytes) + ECC(276 bytes)
- 6) 2646 bytes: Sync(12 bytes) + Header(4 bytes) + Subheader(8 bytes) + User data(2048 bytes) + EDC(4 bytes) + ECC(276 bytes) + byte error flag(294 bytes)

CD-ROM XA or CD-I Mode 2 Form 2 Data Format

- 1) 2336 bytes: Subheader(8 bytes) + Mode 2 Form 2 data(2324 bytes) + Reserved or EDC(4 bytes)
- 2) 2340 bytes: Header(4 bytes) + Subheader(8 bytes) + Mode 2 Form 2 data(2324 bytes) + Reserved or EDC(4 bytes)
- 3) 2352 bytes: Sync(12 bytes) + Header(4 bytes) + Subheader(8 bytes) + Mode 2 Form 2 data(2324 bytes) + Reserved or EDC(4 bytes)
- 4) 2646 bytes: Sync(12 bytes) + Header(4 bytes) + Subheader(8 bytes) + Mode 2 Form 2 data(2324 bytes) + Reserved or EDC(4 bytes) + byte error flag(294 bytes)

For CD-ROM mode 2 data blocks, a read command, with a block length of 2336, 2340 or 2352 and L-EC enabled, will be terminated with a CHECK CONDITION status. The sense key will be set to ILLEGAL REQUEST and the additional sense code set to ILLEGAL MODE FOR THIS TRACK(64h).

For CD-XA and CD-I mode 2 form 2 data blocks, the drive will go ahead to perform the read operation with L-EC off for a read command with block length of 2336, 2340, 2352, or 2646 and DCR(disable correction) bit in Mode Select page 1 set to 0(L-EC enabled). This is required to read interleaved mode 2 form 1 and mode 2 form 2 sectors without modifying the DCR bit with a MODE SELECT command.

Each page descriptor specifies parameters for the target to use for subsequent operations on the specified logical unit. Each page descriptor contains a page code, a page parameter length, and a set of mode parameters. All supported Mode Select pages are specified in section 4.4. The page parameter length field specifies the length in bytes of the parameters that follow the page parameter length field for that page. The initiator will set this value to the value that is returned in the parameter length field for the same page by the MODE SENSE(6) command. If this condition is not met, the controller will terminate the command with a CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to INVALID FIELD IN PARAMETER LIST(26h).

4.3.1.3. READ(6/10/12) Command (08h/28h/A8)

Following notes and statements need to be added to support reading CD-R media.

If unwritten block is detected, the data transfer is terminated with a CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to UNWRITTEN AREA ENCOUNTERED.

If Link, Run-in or Run-out block is detected, the data transfer is terminated with a CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to LINK BLOCKS ENCOUNTERED.

NOTE: The drive uses to read the blocks in the track written by Fixed Packet Recording. Then user data blocks of each Packet are regarded as contiguous data. (i.e. Link, Run-in and Run-out are excluded.)

If a nonexistent logical block arisen from Addressing Method-2 is detected, the data transfer is terminated with a CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to NONEXISTENT BLOCK ENCOUNTERED.

4.3.1.4. READ CD-ROM CAPACITY Command (25h)

Following notes and statements need to be added to support reading CD-R media.

The capacity is based on the starting address of the lead-out area of the last finalized session minus one.

The Logical Block Address reports the address of the last user accessible block of the last finalized session on the disc based on the block length specified in the MODE SELECT(6) command. The default block length is used if a MODE SELECT(6) command has not been issued. If a finalized session does not exist on the disc, Logical Block Address is set to 0.

The Block Length reported is based on the block size requested in the MODE SELECT(6) command. The default block length default is reported if a MODE SELECT(6) command has not been issued. If a finalized session does not exist on the disc, Block Length is set to 0.

4.3.1.5. READ ALL SUBCODES Command (DFh)

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Operation Code (DFh)							
1	Logical Unit Number			Reserved			PS	Reserved
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Transfer Length (MSB)							
7	Transfer Length							
8	Transfer Length							
9	Transfer Length (LSB)							
10	Reserved							
11	Control Byte							

The READ ALL SUBCODES command requests that the target transfer raw subcode data (P~W) to the initiator while the target is playing audio.

The initiator must wait for the current subcode data to be read from the disc.

The purge subcode (PS) bit is used to control the subcode buffering.

If PS bit is equal to 1, all subcode data currently in the buffer is deleted. The initiator must wait for the current subcode data to be read from the disc.

If PS bit is equal to 0, any subcode data currently in the buffer is transferred to the target.

The Transfer Length specifies the number of contiguous subcode frames (96 bytes) that will be transferred. A transfer length of zero indicates that no subcode data will be transferred. A transfer length of zero will not be considered an error. Any other value indicates the number of subcode frames that will be transferred.

If the target's subcode buffer overflows, the target will stop buffering subcode data. This command will terminate with a CHECK CONDITION STATUS if a buffer overflow occurred and there is no more valid subcode data in the buffer. The sense key is set to 05h and the additional sense code is set to BFh. The buffer overflow CHECK CONDITION STATUS only applies to the READ ALL SUBCODES command. All other commands, including READ SUBCHANNEL, will respond as usual.

If the target is not playing audio, this command will terminate with a CHECK CONDITION STATUS. The sense key is set to 05h and the additional sense code is set to 64h (Illegal mode for this track).

NOTE: In the Read All Subcodes command, the returned R~W Subcodes are accurately aligned to CD block boundary.

If the Subcode ECC bit of CD-R Mastering Information Page (20h) is 0, the ECC error of Subcode P~W will be always ignored.

If the Subcode ECC bit of CD-R Mastering Information Page (20h) is 1 and the ECC error of Subcode P~W occurs, the READ ALL SUBCODES command will be terminated with the CHECK CONDITION status. The sense key is set to MEDIUM ERROR and the additional sense code is set to SUBCODE ECC UNRECOVERED ERROR.

4.3.1.6. READ CD-DA Command (D8h)

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Operation Code (D8h)							
1	Logical Unit Number			Reserved	FUA	Reserved		
2	Starting Logical Block Address (MSB)							
3	Starting Logical Block Address							
4	Starting Logical Block Address							
5	Starting Logical Block Address (LSB)							
6	Transfer Length (MSB)							
7	Transfer Length							
8	Transfer Length							
9	Transfer Length (LSB)							
10	Sub Code							
11	Control Byte							

The READ CD-DA command requests that the controller transfer CD-DA data and Sub-Q data to the initiator.

See the READ(10) command for a complete description of the FUA field in this command.

The Starting Logical Block Address specifies the block at which the operation will begin. The starting logical block address is defined as follows:

$$\text{Starting Logical Block Address} = (M-0)*60*75+(S-2)*75+(F-0)$$

(M,S,F) is the absolute MSF address of the requested starting logical block address.

Table 4-6 The Sub Code Field

Sub Code Field	CD-DA Block Length	Description
00h	2352 bytes	CD-DA data with no Sub Code
01h	2368 bytes	CD-DA data with Sub-Q Code
02h	2448 bytes	CD-DA data with all Sub Code
03h	96 bytes	All Sub Code only
04-FFh		Reserved

The Sub Code field set to 00h requests that the drive returns the CD-DA data with no Sub Code data. Then the each block consists of 2352 bytes of digital audio data without any Sub Code data.

The returned CD-DA data always starts with the left channel lower order 8 bits. The ordering of the returned CD-DA data is as follows:

- 1) Left channel lower 8 bits.
- 2) Left channel higher 8 bits.
- 3) Right channel lower 8 bits.
- 4) Right channel higher 8 bits.

The Sub Code field set to 01h requests that the drive returns the CD-DA data with Sub-Q data. Then the each block consists of 2368 bytes which has 2352 bytes of digital audio data, 10 bytes of Sub-Q data ((96-16)bits, because the 16 bits of CRC is removed), and 6 bytes of Zeros. The CRC error of Subcode-Q will be always ignored.

The ten sub-Q data byte has the following ordering.

- Byte0 : Control (4.M.S. bits), ADR(4.L.S. bits).
- Byte1 : Track number (BCD).
- Byte2 : Index number (BCD).
- Byte3 : Min (BCD).
- Byte4 : Sec (BCD).
- Byte5 : Frame (BCD).
- Byte6 : Reserved (00h).
- Byte7 : A Min (BCD).
- Byte8 : A Sec (BCD).
- Byte9 : A Frame (BCD).

The Sub-Q Code field set to 02h requests that the drive returns the CD-DA data with all Sub Code data. Then the each block consists of 2448 bytes which has 2358 bytes of digital audio data and 96 bytes of Sub Code data. If the Subcode ECC bit of CD-R Mastering Information Page (20h) is 0, then the ECC error of Subcode P~W will be always ignored. If the Subcode ECC bit of CD-R Mastering Information is 1 and the ECC error of Subcode P~W occurs, the READ CD-DA command will be terminated with the CHECK CONDITION status. The sense key is set to MEDIUM ERROR and the additional sense code is set to SUBCODE ECC UNRECOVERED ERROR.

The Sub-Q Code field set to 03h requests that the drive returns 96 bytes of all Sub Code data only. If the Subcode ECC bit of CD-R Mastering Information Page (20h) is 0, then the ECC error of Subcode P~W will be always ignored. If the Subcode ECC bit of CD-R Mastering Information is 1 and the ECC error of Subcode P~W occurs, the READ CD-DA command will be terminated with the CHECK CONDITION status. The sense key is set to MEDIUM ERROR and the additional sense code is set to SUBCODE ECC UNRECOVERED ERROR.

NOTE: For Sub Code field of 02h or 03h, the returned P~Q Subcodes are accurately aligned to the CD block boundary, but the R~W subcodes may have one pocket (i.e. twenty four subcode bytes) time advance offset from the P~Q subcodes.

The Transfer Length specifies the number of contiguous CD-DA data blocks that will be transferred.

NOTE: These CD-DA block lengths have no relation to the Logical Block Length set by the MODE SELECT (6) command. The Block Length field in the MODE SELECT command would not be changed by this command.

NOTE: As long as the SCSI buffer is not full, the drive can provide correct data for consecutive read commands to read contiguous CD-DA blocks. There is no overlap or missing bits for the contiguous CD-DA blocks between the consecutive read commands. If the initiator can read the CD-DA data out of the buffer fast enough, the drive will refill the buffer with new CD-DA data from the media.

If the initiator can not read the data fast enough and the buffer is full, the drive will stop refilling the buffer. The initiator can still read all CD-DA data in the SCSI buffer with consecutive read commands without overlap or missing bits at the block boundary. After the buffer is full, the first read command to read the next sequential CD-DA block(e.g. X+1) after the last CD-DA block(e.g. X) in the buffer, will cause a Check Condition with a sense key of 05h and an additional sense code of BFh(buffer overflow). There is no CHECK CONDITION for a read command that do not request block X+1(e.g. a Read(X+2, 1) command). In addition, a second read command that requests block X+1 will not get a CHECK CONDITION.

For example:

In a Read(X-2, 5) command to read block X-2 to X+2, the drive returns five CD-DA data blocks and then a CHECK CONDITION. The drive returns the block X+1 address in the information bytes(byte 3 to 6) of a subsequent Request Sense command. There are no overlap or missing bits for blocks X-2, X-1 and X. It may have missing or overlap bits between block X and X+1, because in case of CD-DA blocks, once the data stream from the media has been stopped, the drive has only rough access, and can not have such pin-point access as in CD-ROM blocks.(Each CD-ROM block always includes the CD-ROM Header that provides the pin-point access.)

NOTE: Software volume level control will not be performed on any SCSI CD-DA data. Analog audio output will not be performed while SCSI CD-DA data is being transferred.

When a C2PO bit of CD-R Mastering Information Page (20h) is 0, even if the C2PO error occurs, the READ CD-DA command will complete with GOOD status.

When a C2PO bit of CD-R Mastering Information Page (20h) is 1 and the C2PO error occurs, the READ CD-DA command will be terminated with the CHECK CONDITION status. The sense key is set to MEDIUM ERROR and the additional sense code is set to SUBCODE ECC UNRECOVERED ERROR.

4.3.1.7. READ CD-DA MSF Command (D9h)

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Operation Code (D9h)							
1	Logical Unit Number			Reserved	FUA	Reserved		
2	Reserved							
3	Starting M Field							
4	Starting S field							
5	Starting F field							
6	Reserved							
7	Ending M Field							
8	Ending S Field							
9	Ending F Field							
10	Sub Code							
11	Control Byte							

The READ CD-DA MSF command requests that the controller transfer CD-DA data to the initiator.

See the READ(10) command for a complete description of the FUA field in this command.

The Starting M, S, F, fields specifies the absolute MSF address at which the operation will begin.

See the Read CD-DA command for a description of the Sub Code field and CD-DA Block Length.

The Ending M, S, F, field specifies the absolute MSF address at which the operation will finish. If the ending address is less than the starting address, a CHECK CONDITION status is returned. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to INVALID FIELD IN CDB(24h).

The data transfer length (bytes) can be calculated as follows:

The data transfer length = $\{(Me - Ms) * 60 * 75 + (Se - Ss) * 75 + (Fe - Fs)\}$
 $\quad \quad \quad * (CD\text{-}DA \text{ Block Length})$

Ms, Ss, Fs: the starting MSF address

Me, Se, Fe: the ending MSF address

4.3.1.8. READ TOC Command (43h)

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Operation Code (43h)							
1	Logical Unit Number			Reserved			MSF	Reserved
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Starting Track/Session Number							
7	Allocation Length (MSB)							
8	Allocation Length (LSB)							
9	Format		Control Byte					

The READ TOC command requests the target to transfer Table of Contents(TOC) data of the finalized session on a disc to the initiator. This command is provided for compatibility with Conventional CD-ROM drive.

This command is modified from the SCSI-2 Read TOC command with the addition of the Format field and the Session Number field to support multi-session disc.

If a finalized session does not exist on the disc, this command is terminated with the CHECK CONDITION status. The sense key is set to NOT READY and the additional sense code is set to NO TABLE-OF-CONTENTS.

The Format field is defined below.

Format

- 00b Same definition as in SCSI-2. The Start Track/Session Number field specifies starting track number for which the data will be returned.
For multi-session disc, this command will return the TOC data for all sessions.
- 01b This format returns the first finalized session number, last finalized session number and last finalized session starting address.
In this format, the Starting Track/Session Number field is reserved and should be set to 00h.
NOTE: This format provides the initiator to access the last finalized session starting address quickly.
- 10b This format returns all Q subcodes data in the lead in(TOC) area starting from a specified session number as specified in the Session Number field. In this mode, the drive will support Q Subcode Point field value of A0h,A1h,A2h,Track numbers, B0h,B1h,B2h,B3h,B4h and C0h.
- 11b Reserved.

The Starting Track field specifies the starting track number for which the TOC data will be returned. The data is returned in contiguous ascending order. Valid values for the starting track field are 0h to 63h. A value of AAh requests that the starting address of the lead out area be returned. If this value is zero, the table of contents data will begin with the first track on the disc.

If the Track Number field is not valid for the disc inserted, the command will be terminated with a CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST. The additional sense code is set to ILLEGAL VALUE IN CDB.

NOTE: CD-I disc format does not have track descriptor for CD-I tracks. It has track descriptor for each CD-DA tracks.

For Format = 00b, the returned data of READ TOC Command is defined as follows.

TOC Data With Format Field = 00b

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	TOC Data Length (MSB)							
1	TOC Data Length (LSB)							
2	First Track Number							
3	Last Track Number							

TOC Track Descriptor(s)

0	Reserved	
1	ADR	Control
2	Track Number (Hex)	
3	Reserved	
4	Absolute CD-ROM Address (MSB)	
5	Absolute CD-ROM Address	
6	Absolute CD-ROM Address	
7	Absolute CD-ROM Address (LSB)	

The TOC data returned is a four byte header followed by one or more TOC track descriptors. The last track descriptor is for the lead-out area. The format of the CD Address is determined by the MSF bit in the CDB.

The TOC data length specifies the length in bytes of the available table of contents data. The value of TOC data length does not include TOC data length field itself.

The First Track Number field indicates the first track number in the table of contents.

The Last Track Number field indicates the last track number in the table of contents before the lead-out track number.

IMPLEMENTORS NOTE:

A disc may start at any track number greater than zero. The track numbers between the first track number and the last track number are in contiguous ascending order, except for the lead-out track which has a track number of AAh.

The ADR field is defined in the Read Q Sub-Channel command.

The Control field indicates the attributes of the track. It is defined in the Read Q Sub-Channel command.

The Track Number field indicates the track number for which the data in the TOC track descriptor is valid.

The Absolute CD-ROM Address contains the address of the first block with user information for that track number as read from the table of contents. An MSF bit of zero indicates that the Absolute CD-ROM Address field contains a logical block address. An MSF bit of one indicates the Absolute CD-ROM Address field contains an MSF address.

IMPLEMENTORS NOTE:

The starting logical block address value recovered from the TOC has a tolerance of zero for data tracks and plus or minus 75 CD sectors for audio tracks. This tolerance is multiplied by a factor dependent on the Logical Block Length.

For Format = 01b, the returned data of READ TOC Command is defined as follows.

TOC Data With Format Field = 01b

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	TOC Data Length (0Ah) (MSB)							
1	TOC Data Length (LSB)							
2	First Session Number							
3	Last Session Number							

TOC Track Descriptor(s)

0	Reserved	
1	ADR	Control
2	First Track Number in Last Session	
3	Reserved	
4	Absolute CD-ROM Address of First Track In Last Session (MSB)	
5	Absolute CD-ROM Address of First Track In Last Session	
6	Absolute CD-ROM Address of First Track In Last Session	
7	Absolute CD-ROM Address of First Track In Last Session (LSB)	

For Format = 10b, the returned data of READ TOC Command is defined as follows.

TOC Data With Format Field = 10b

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	TOC Data Length (MSB)							
1	TOC Data Length (LSB)							
2	First Session Number							
3	Last Session Number							

TOC Track Descriptor(s)

0	Session Number	
1	ADR	Control
2	Byte 1 or TNO	
3	Byte 2 or Point	
4	Byte 3 or Min	
5	Byte 4 or Sec	
6	Byte 5 or Frame	
7	Byte 6 or Zero	
8	Byte 7 or PMin	
9	Byte 8 or PSec	
10	Byte 9 or PFrame	

For Format field of 10b, the drive should return TOC data for Q-subcode modes(ADR field) 1 and 5 (except mode 5, point 1 through 40) in the lead in area.

The First Session Number is equal to the Last Session Number for single session disc.

The returned TOC data of a multi-session disc is arranged in ascending order of the session number. The TOC data within a session is arranged in the order of Q Subcode Point field value of A0h, A1h, A2h, Track Numbers, B0h, B1h, B2h, B3h, B4h and C0h.

4.3.2. CD-R Command Descriptions

The following table lists the commands implemented in the target. This list is written by the alphabetical order. The command descriptions are in alphabetical order by command name.

Table 4-7 Implemented Commands

Command Name	Command code	Type	Section
CLOSE TRACK	5Ah	M	4.3.2.1
DISCONTINUE	52h	O	4.3.2.2
FINALIZE	5Bh	M	4.3.2.3
FLUSH	5Dh	O	4.3.2.4
READ BUFFER CAPACITY	5Ch	O	4.3.2.5
READ MASTER CUE	59h	M	4.3.2.6
RECOVER TRACK	5Fh	O	4.3.2.7
RESERVE TRACK	53h	M	4.3.2.8
WRITE (6)	0Ah	M	4.3.2.9
WRITE (10)	2Ah	M	4.3.2.9
WRITE CONTINUE	51h	M	4.3.2.10
WRITE START	50h	O	4.3.2.11
WRITE TRACK	5Eh	M	4.3.2.12

M: Mandatory O: Optional V: Vendor Unique

4.3.2.1. CLOSE TRACK Command (5Ah)

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Operation Code (5Ah)							
1	Logical Unit Number				Reserved			
2	Reserved							Padding
3	Reserved							
4	Reserved							
5	Track Number							
6	Reserved							
7	Reserved							
8	Reserved							
9	Control							

The CLOSE TRACK Command requests that the drive close a specified track on a disc. ('close' means the drive turns the track into Complete Track.) This command is available for a track written by Packet Recording or Track at Once Recording.

Padding bit is defined according to the following each case.

Track Number field specifies the track number of a track which will be closed.

In case of Packet Recording, a specified track closes as follows.

1) Invisible Track

If a specified track is Invisible Track, the track is not closed. Then the CLOSED TRACK command is terminated with the CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to ILLEGAL TRACK STATUS.

2) Incomplete Track

If a specified track is Incomplete Track, the track length of the track is fixed by writing of Begin and End address in PMA and the track becomes Complete Track.

If (Starting LBA of the Track - Next Recordable Address) $\cdot 4 \cdot 75$, the CLOSED TRACK command is terminated with the CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and additional sense code is set to INAPPROPRIATE COMMAND.

3) Empty Reserved Track

If a specified track is Empty Reserved Track, the track is not closed. Then the CLOSED TRACK command is terminated with the CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to ILLEGAL TRACK STATUS.

4) Partly Recorded Reserved Track

If a specified track is Partly Recorded Reserved Track with Padding=0, the track is not closed. Then the CLOSED TRACK command is terminated with the CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to ILLEGAL TRACK STATUS.

If the padding bit is 1, the unwritten area of the track is padded with 00h and the track becomes Complete Track.

If (Starting LBA of the Track - Next Recordable Address) $\cdot 4 \cdot 75$, the CLOSED TRACK command is terminated with the CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and additional sense code is set to INAPPROPRIATE COMMAND.

In case of Track at Once Recording, a specified track closes as follows.

5) during Track at Once Recording for Invisible Track

If a specified track is Invisible Track during Track at Once Recording, the track length of the track is fixed by writing of Begin and End address in PMA and writing of the track closes.

If the initiator issues the CLOSE TRACK command with Padding=0 and the total length of user data of the track which is sent by WRITE CONTINUE commands is not the multiple of the block length (see MODE SELECT command), the CLOSE TRACK command is terminated with the CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to BUFFER DATA SIZE ERROR.

If the block length is 512 bytes or 1024 bytes in the above case, the total length of user data of a track must be the multiple of 2048 bytes.

If the Padding bit is 1, the CLOSE TRACK command is terminated with the CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to INAPPROPRIATE COMMAND.

If (Starting LBA of the Track - Next Recordable Address) $\cdot 4 \cdot 75$, the CLOSED TRACK command is terminated with the CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to INAPPROPRIATE COMMAND.

6) during Track at Once Recording for Empty Reserved Track

If a specified track is Empty Reserved Track during Track at Once Recording and the total length of user data of the track which is sent by WRITE CONTINUE commands is not the multiple of the block length (see MODE SELECT command), the CLOSE TRACK command is terminated with CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to BUFFER DATA SIZE ERROR.

If the total length of the user data of the track which is sent by WRITE CONTINUE commands with Padding=0 is smaller than "Capacity of Blank Area * Block Length", the CLOSE TRACK command is terminated with CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to ILLEGAL TRACK STATUS.

If the total length of the user data of the track which is sent by WRITE CONTINUE commands with Padding=1 is smaller than "Capacity of Blank Area * Block Length", the blank area of the track is padded with 00h and the track becomes Complete Track.

If the total length of user data of the track which is sent by WRITE CONTINUE commands is equal to "Capacity of Block Area * Block Length", the drive does not regard it as error.

If (Starting LBA of the Track - Next Recordable Address) $\cdot 4 \cdot 75$, the CLOSED TRACK command is terminated with the CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and additional sense code is set to INAPPROPRIATE COMMAND.

7) Complete Track

If a specified track is Complete Track, the CLOSED TRACK command is terminated with the CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to ILLEGAL TRACK STATUS.

4.3.2.2. DISCONTINUE Command (52h)

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Operation Code (52h)							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	Reserved							
8	Reserved							
9	Reserved						flag	link

The DISCONTINUE command discontinues Disc at Once Recording.

If the drive accepts this command during Disc at Once Recording, the drive aborts writing operation and ejects a caddy.

The disc which is aborted by this command is illegal because the disc does not follow CD standards.

If DISCONTINUE command is issued in a condition except Disc at Once Recording, this command is terminated with the CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional Sense code is set to INAPPROPRIATE COMMAND ERROR.

4.3.2.3. FINALIZE Command (5Bh)

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Operation Code (5Bh)							
1	Logical Unit Number			Reserved				
2	Reserved							Padding
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	Reserved							
8	Next Session							
9	Control							

The FINALIZE Command requests the drive to write Lead in and Lead out area and to finalize the last session in a disc. ('finalize' means the drive turns all track in a session into Complete Track and writes the Lead in and Lead out track in the session.)

If the last track in a disc is Invisible Track, all tracks in last session except Invisible Track are finalized.

If the last track in a disc is Incomplete Track, the drive closes Incomplete Track before finalizing.

If Empty Reserved Track or Partly Written Reserved Track is included in the last session in a disc and Padding bit of the FINALIZE command is 0, the FINALIZE command is terminated with the CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to RESERVED TRACK PRESENT.

If Empty Reserved Track or Partly Written Reserved Track is included in the last session in a disc and Padding bit of the FINALIZE command is 1, the drive closes the Reserved Track before finalizing.

If Damaged Track is included in the last session in a disc, the FINALIZE command is terminated with the CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to DAMAGED TRACK PRESENT.

If (Starting LBA of the Track - Next Recordable Address) • 4*75, the FINALIZE command is terminated with the CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to INAPPROPRIATE COMMAND.

Next Session field specifies whether the next session is valid or not.

Code	Description
00h	Not Allowed Next Session
01h	Allowed Next Session

If the FINALIZE command with Next Session code=01h is issued for Audio disc, the FINALIZE command is terminated with the CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is DISC STYLE MISMATCH.

NOTE: If a disc is Single-Session and Next Session code is 00h, Sub-Q data of Mode 5 Point=B0 is not written in Lead in area.
If a disc is Multi-Session and Next Session code is 00h, Sub-Q data of Mode 5 Point=B0 is written in Lead in area. Then the value of MIN, SEC and FRAME of Sub-Q data are FFh.
If Next Session code is 01h, the head address of Program area of next session is written in the MIN, SEC and FRAME of Sub-Q data of Mode 5 Point=B0.

4.3.2.4. FLUSH Command (5Dh)

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Operation Code (5Dh)							
1	Logical Unit Number				Reserved			
2	Reserved							Padding
3	Partial Flush							
4	Reserved							
5	Track Number							
6	Reserved							
7	Reserved							
8	Reserved							
9	Control							

The FLUSH Command requests the drive to write the cached data in buffer into a specified track. The cached data in buffer is sent by the WRITE commands in the following case.

WCE bit of CD-R Write Cache Page is 1.

The Track Information Page of the specified track number is as follows.

Capacity of the Blank Area > 0

Write Method = 01h/02h (Fixed Packet/Variable Packet)

If the FLUSH command is issued in case that WCE bit of CD-R Write Cache Page is 1, this command is terminated with the CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional Sense code is set to INAPPROPRIATE COMMAND ERROR.

If the Track Number field is zero, the last track number is specified by this command.

1. The FLUSH Command in case of Fixed Packet

All cached data in buffer are written on a disc if the data length are the multiple of the Packet Length.

If the data length are not the multiple of the Packet Length, the FLUSH Command has the following three actions.

1-1. The case of Padding=0 and Partial Flush=00h

The FLUSH command is terminated with the CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to BUFFER DATA SIZE ERROR.

1-2. The case of Padding=0 and Partial Flush=01h

The divisible part of the data is written on a disc. The remainder is left in buffer.

For example, this command is used to get some blank area in buffer when buffer is almost full.

1-3. The case of Padding=1 and Partial Flush=01h

The drive adds the remainder to 00h until Packet Length and all data are written on a disc. This command is used to force a track to close.

In case of Padding=1 and Partial Flush=00h, the FLUSH command is always terminated with the CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to INVALID FIELD IN CDB.

2. The FLUSH Command in case of Variable Packet

All cached data in buffer are written as one Packet on a disc. The Packet Length is equal to the length of data in buffer. Padding field and Partial Flush field are invalid in this case.

4.3.2.5. READ BUFFER CAPACITY Command (5Ch)

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Operation Code (5Ch)							
1	Logical Block Number			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	Reserved							
8	Reserved							
9	Reserved						flag	link

The READ BUFFER CAPACITY command checks the total length of buffer and the length of blank area of it.

The drive reports the length of the buffer only during Track at Once Recording or Disc at Once Recording. This buffer is for data sent by the WRITE CONTINUE command. If the READ BUFFER CAPACITY command is issued in the condition except Track at Once Recording or Disc at Once Recording, the Blank Length of Buffer field is invalid.

The READ BUFFER CAPACITY data shown below is sent during the DATA IN phase of this command.

READ BUFFER CAPACITY data

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Reserved							
1	The Length of Buffer (MSB)							
2	The Length of Buffer							
3	The Length of Buffer (LSB)							
4	Reserved							
5	Blank Length of Buffer (MSB)							
6	Blank Length of Buffer							
7	Blank Length of Buffer (LSB)							

The Length of Buffer indicates the whole capacity of the buffer in bytes. The Blank Length of Buffer indicates the length of unused area of the buffer in bytes.

4.3.2.7. RECOVER TRACK Command (5Fh)

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Operation Code (5Fh)							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Track Number							
6	Reserved							
7	Reserved							
8	Reserved							
9	Control							

The RECOVER TRACK command will be used to recover the Damaged Track. The Damaged Track is the track where the drive is not able to write additionally because the last packet of the track is broken (e.g. in case that the drive terminated to write by mechanical shock).

The Track Number field specifies the track number of the Damaged Track to be recovered.

If the Track Number field is zero, the last track number is specified by this command.

If the damaged track have small writable area with length less than one subcode frame (e.g. in Partly Recorded Reserved Track), the RECOVER TRACK command is terminated with Check Condition status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to UNRECOVERABLE DAMAGED TRACK CAUSE TOO SMALL WRITABLE AREA.

After successful execution of this command, the Track Status of the track turns into one of the following status:

In case of Packet Recording,
 Complete Track
 Incomplete Track
 Partly Written Reserved Track

In case of Track at Once Recording,
 Complete Track

NOTE: There are some blocks which is unable to read in the recovered track.

4.3.2.8. RESERVE TRACK Command (53h)

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Operation Code (53h)							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserve Length (MSB)							
6	Reserve Length							
7	Reserve Length							
8	Reserve Length (LSB)							
9	Control							

The RESERVE TRACK Command reserves the area for data track in a disc. ('reserve' means the drive writes track number and the Starting address and Ending address of the data track in the PMA.) Only data track can be reserved by this command, no audio track can be reserved.

For this command, the drive specifies the track number of the track automatically. The track number is equal to the number indicated by Last Track Number of Disc Information Page before execution of this command.

Reserve Length fields specify the number of contiguous logical blocks for user data area (except pre-gap and post-gap) of the track which will be reserved. The number specified by Reserved Length field must be smaller than the number indicated by Capacity of Blank Area of Track Information Page of the track before execution of this command.

If Reserve Length is smaller than $4 \times 75 = 300 = 12\text{Ch}$ (4 seconds), this command is terminated with the CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to ILLEGAL RESERVE LENGTH FOR RESERVE TRACK COMMAND.

If a last track is Incomplete Track and Reserve Length is smaller than the total length of packet written in the track, this command is terminated with the CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to ILLEGAL RESERVE LENGTH FOR RESERVE TRACK COMMAND.

In case of Fixed Packet Recording (i.e. in case that the Write Method of Track Information Page indicates "Packet Recording (Fixed Packet)", if Reserve Length is not multiple of fixed packet size indicated by Fixed Packet Size of Track Information Field, this command is terminated with the CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to ILLEGAL RESERVE LENGTH FOR RESERVE TRACK COMMAND.

If a last track is Invisible Track and the Data Form of Track Information Page of the track is not same as of previous track, the RESERVE TRACK command is terminated with the CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to ILLEGAL DATA FORM FOR RESERVE TRACK COMMAND.

If a last track is not Invisible Track and the Data Form of Track Information Page of the track is not same as of previous track, the RESERVE TRACK command is terminated with the CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to UNABLE TO RESERVE TRACK, BECAUSE TRACK MODE HAS BEEN CHANGED.

If a track is Invisible Track and the Write Method of Track Information Page of the track indicates Packet Recording (Fixed Packet) or Packet Recording (Variable Packet), the track status turns into Partly Recorded Reserved Track after successful execution of this command.

If a track is Invisible Track and the Write Method of Track Information Page of the track indicates Track At Once Recording, the track status turns into Empty Reserved Track after successful execution of this command.

If a track is Incomplete Track, the track status turns into Partly Recorded Reserved Track after successful execution of this command.

4.3.2.9. WRITE (6/10) Command (0Ah/2Ah)

The WRITE Command requests that the drive receive user data from the initiator and write the data on a disc. In case of Write Cache Enable, the user data is sent to buffer of the drive and is not written on the disc.

The WRITE command is available only in case of writing for the track which write method is specified as Packet Recording. Then Logical Block Address must be equal to NRA in Track Information Page of the track. If Logical Block Address is not equal to NRA in Track Information Page of the track, the WRITE command is terminated with the CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to INVALID FIELD IN CDB.

If a track specified by the WRITE command is Invisible Track or Empty Reserved Track, the drive writes Pre-gap on a disc automatically before writing of all Packets.

Writing in case of Write Cache Disable

The initiator writes one Packet by one WRITE command. Transfer Length of the WRITE command must be equal to Packet length. The Packet length must be smaller than buffer length of the drive. If the Packet is Fixed Packet, the Transfer Length must be equal to the value of Fixed Packet Size field in Track Information Page.

The drive writes all data specified by this command on a disc and then the GOOD status is returned.

Writing in case of Write Cache Enable

The initiator sets WCE (Write Cache Enable) bit of Write Cache Page in MODE SELECT to 1 in order to change the mode to Write Cache Enable.

When the mode is changed to Write Cache Enable, the data sent from the initiator by the WRITE command is stored in the buffer of drive, and is written on a disc after issue of the FLUSH command.

The data of NRA, Capacity of the Blank and buffer in case of Write Cache Enable

In Write Cache Enable status, some data sent from the initiator by some WRITE commands are stored as contiguous blocks in the buffer. However, the value of NRA and Capacity of Blank Area filed in Track Information Page is revised at every the WRITE command. It is available only in case that LBA of each WRITE command and Transfer Length satisfy the following conditions.

LBA:

The NRA is the address added 1 to the address of the last block of a series data stored in buffer. For more details, see NRA field of Track Information Page. If there is cached data in the buffer, the Logical Block Address of the WRITE command must be always equal to the address added 1 to the address of the last block of a series data stored in buffer.

Transfer Length:

Transfer Length must be smaller than the value of Capacity of the Blank and than blank size of buffer.

Blank size of buffer =

Buffer length - the length of data stored in buffer

'The length of data stored in buffer' is the total of Transfer Length of the WRITE command executed after the last FLUSH command.

If the initiator requests the WRITE command for Transfer Length which does not satisfy the above conditions, the WRITE command is terminated with the CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to INVALID FIELD IN CDB. The NRA and Capacity of the Blank are not revised.

In Write Cache Enable status, the initiator only sends the data in the buffer of the drive by the WRITE command. The FLUSH command is used to write the data of the buffer on a disc. The behavior of the FLUSH command is according to Write method(Fixed Packet or Variable Packet). For more details, see 4.3.2.4. the FLUSH command.

4.3.2.10. WRITE CONTINUE Command (51h)

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Operation Code (51h)							
1	Logical Unit Number			Byte Transfer length (MSB)				
2	Byte Transfer length							
3	Byte Transfer length (LSB)							
4	Reserved							
5	Reserved							
6	Reserved							
7	Reserved							
8	Reserved							
9	Control							

The WRITE CONTINUE Command requests the initiator to send the user data so that the drive continues Disc at Once Recording or Track at Once Recording.

The WRITE CONTINUE command is available after execution of the WRITE TRACK command or the WRITE START command. (i.e. during Disc at Once Recording or Track at Once Recording.)

If the WRITE CONTINUE command is issued in the condition except the above, the WRITE CONTINUE command is terminated with the CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to INAPPROPRIATE COMMAND ERROR.

The data sent by the WRITE CONTINUE command is always stored in the buffer of the drive and is written at the constant speed on a disc. If the issue of the WRITE CONTINUE command is late during write and the user data of buffer becomes empty, the writing is aborted and the sense key is set to UNIT ATTENTION and the additional sense key is set to BUFFER ERROR DURING DISC AT ONCE OR TRACK AT ONCE RECORDING.

Byte Transfer Length field specifies the number of bytes of the total data sent during Data Out Phase of this command.

When the drive receives last data, the drive disconnects, if possible.

In case of Disc at Once Recording, after writing all data, the drive reconnects and terminates this command even if the data transferred during DATA OUT phase is less than Transfer Block Length, and then the drive returns the CHECK CONDITION status. The sense key is set to UNIT ATTENTION and the additional sense code is set to WRITE COMPLETE.

4.3.2.11. WRITE START Command (50h)

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Operation Code (50h)							
1	Logical Unit Number			Reserved	Cue Sheet length (MSB)			
2	Cue Sheet Length							
3	Cue Sheet Length (LSB)							
4	Reserved							
5	Reserved							
6	Reserved							
7	Reserved							
8	Reserved							
9	Reserved						flag	link

The WRITE START command requests the drive receive the Cue Sheet during DATA OUT phase and start Disc at Once Recording.

The WRITE START command is acceptable in case that a disc is Blank Disc and Disc Style is Uninterrupted. See 4.4.1.3 CD-R Disc Information Page.

The Cue Sheet Length specifies the length in bytes of the Cue Sheet that is transferred during DATA OUT phase.

See 4.6 about the Cue Sheet.

If WRITE START command is issued during write, the CHECK CONDITION status is returned, and the sense key is set to ILLEGAL REQUEST and additional sense code is set to INAPPROPRIATE COMMAND ERROR.

If WRITE START command is issued with illegal Cue Sheet data bytes during Data Out phase, the command will be terminated with the CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to ILLEGAL CUE SHEET(88h). The byte 3 (MSB), 4, 5 and 6 (LSB) in additional sense bytes (see 4.5.3. additional sense bytes) are set to the Cue Sheet Error Code defined in Appendix A.

4.3.2.12. WRITE TRACK Command (5Eh)

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Operation Code (5Eh)							
1	Logical Unit Number				Reserved			
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved Track Number							
6	Reserved							
7	Reserved							
8	Reserved							
9	Control							

The WRITE TRACK Command requests the drive to start Track at Once Recording.

The WRITE TRACK command is acceptable for Invisible Track or Empty Reserved Track whose write method is set to Track at Once Recording. (See 4.4.1.3 and 4.4.1.4)

If zero is specified in Reserved Track Number field, the drive starts writing of Invisible Track. If there is no Invisible Track in a disc (i.e. The disc is unrecordable or the last track of it is Incomplete Track), the WRITE TRACK command is terminated with the CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to ILLEGAL TRACK STATUS.

If the number except zero is specified in Reserved Track Number field, the drive starts writing of a track which has the number as the track number. The specified track must be Empty Reserved Track. If the track is not Empty Reserved Track, the WRITE TRACK command is terminated with the CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST and the additional sense code is set to ILLEGAL TRACK STATUS.

The user data is sent to the drive by the WRITE CONTINUE command during Track at Once Recording and is written on a disc.

The CLOSE TRACK command is issued to stop the writing during Track at Once Recording for Invisible Track.

The drive can accept only the following commands during Track at Once Recording.

- WRITE CONTINUE command
- CLOSE TRACK command
- MODE SENSE command
- REQUEST SENSE command
- READ BUFFER CAPACITY command

4.4. Mode Page Descriptions

4.4.1. MODE SELECT Pages

Table 4-8 Mode Select Page Codes

Page Code	Description
01h	Read Error Recovery Parameters Page
02h	Disconnect/Reconnect Control Parameters Page
08h	Caching Page
0Dh	CD-ROM Parameters Page
0Eh	CD-ROM Audio Control Parameters Page
20h	Writing Mode Page
22h	CD-R Disc Information Page
23h	CD-R Track Information Page
31h	Drive Speed Page

4.4.1.1. Caching Page (Page Code 08h)

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	PS	Reserved	Page Code (08h)					
1	Page Length (0Ah)							
2	Reserved					WCE	Reserved	
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	Reserved							
8	Reserved							
9	Reserved							
10	Reserved							
11	Reserved							

The Caching Page specifies the parameter regarding cache.

If WCE bit is zero, the GOOD status for the WRITE command is returned after writing of all data completes successfully on a disc.

If WCE bit is one, the GOOD status for the WRITE command is returned after the drive receives all data without writing of data on a disc.

(i.e. The data is only written in the buffer of the drive and no data is written on a disc.) For the behavior of the WRITE command, see 4.3.2.9. the WRITE Command.

4.4.1.2. CD-R Mastering Information Page (Page Code 20h)

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	PS	Reserved	Page Code (20h)					
1	Page Length (06)							
2	The Offset of Subcode and Header							
3	Reserved			Subcode ECC	C2PO	Int	Pseudo	Reserved
4	Reserved							
5	Cue Sheet Option Code							
6	Reserved							
7	Reserved							

Int (Interleave) :0 Not Interleaving on the Subcode R~W
:1 Interleaving on the Subcode R~W
Pseudo :0 Real Write
:1 Pseudo-Write

The Offset of Subcode and Header indicates the lag of the address in Header for the absolute time in Subcode Q channel. The Offset of Subcode and Header is expressed in 2's complement. See Figure 4-3.

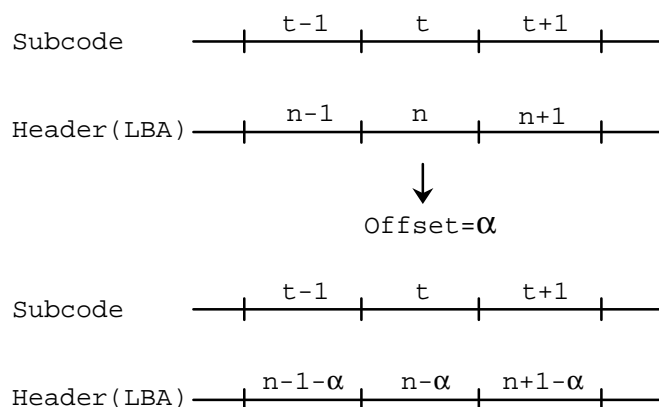


Figure 4-3 The Offset of Subcode and Header

A Subcode ECC bit of 0 indicates that the READ CD-DA command, READ CD-DA MSF command and READ ALL SUBCODE command ignore the ECC error of Subcode P~W.

A Subcode ECC bit of 1 indicates that the READ CD-DA command, READ CD-DA MSF command and READ ALL SUBCODE command report the ECC error of Subcode P~W to the host. For the details, see the READ CD-DA command, READ CD-DA MSF command and READ ALL SUBCODE command.

A C2PO bit of 0 indicates that the READ CD-DA command and READ CD-DA MSF command ignore the C2PO error.

A C2PO bit of 1 indicates that the READ CD-DA command and READ CD-DA MSF command report the C2PO error to the host. For the details, see the READ CD-DA command(D8h).

A Pseudo bit is available in case of Disc at Once Recording.

A Pseudo bit of 0 indicates that the drive writes data on a disc.

A Pseudo bit of 1 indicates that the drive performs the writing operation, but does not write actually data on a disc.

The Cue Sheet Option Code defines a format and process for Cue Sheet.

Cue Sheet Option Code

Cue Sheet Option Code	Generate Master Disc	Check of CD Format	Modify Pre-gap
00	No	Yes	Yes
01	No	Yes	No
02	No	No	Yes
03	No	No	No
04	Yes	Yes	Yes
05	Yes	Yes	No
06	Yes	No	Yes
07	Yes	No	No

Generate Master Disc: The drive writes a Master CD.
In case of writing a Master CD, the drive needs the Master Disc Information in Cue Sheet.

Check of CD Format: The drive checks whether the Cue Sheet conform to a CD Format.

If a initiator selects a Cue Sheet Option Code that "Check of CD Format" is "No", written disc may not conform to a CD Format. Therefore, it is recommended that initiator selects a Cue Sheet Option Code that "Check of CD Format" is "Yes".

The contents of Check is as follows.

- * Each track has a index 01.
- * If the first track on a disc is music track, it is preceded by a pause encoding of 2-3 seconds.
- * If the first track on a disc is data track, it is preceded by a pause encoding of 2 seconds.
- * If a data type specified by DATA FORM is not "music", the CONTROL is "Data track" (01x0).
- * The data type specified by DATA FORM does not change during one track.
- * The CONTROL does not change during one track.
- * The Alternate Copy bit of ZERO does not change during one track.
- * The track number increases by one.
- * Each track has a minimum length of 4 seconds, not including the pause length preceding the track.

Modify Pre-gap: The drive modifies a part of Pre-gap in the Cue Sheet.
See 4.6 about how to modify.

4.4.1.3. CD-R Disc Information Page (Page Code 22h)

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	PS	Reserved	Page Code (22h)					
1	Page Length							
2	Disc Style							
3	Disc Type							
4	First Track Number							
5	Last Track Number							
6	Number of Sessions							
7	Reserved							
8	Disc Application Code							
11								
12	Last Possible Start Time of Lead Out							
15								
Extended Disc Information for CD-R								
16	Disc Status							
17	Number of valid NRA							
18	Track Number of Track Information Page							
19	Post-Gap							
20	Disc Identification Code							
23								
24	Reserved							
31								

The initiator gets or sets the information of a disc inserted in the drive using Disc Information Page. The contents of Disc Information Page is revised when a disc is changed, written or reserved.

D1. Disc Style

Byte	Description
00h	Uninterrupted (Conventional CD or Disc at Once CD-R disc)
80h	Interrupted Audio Disc (Track at Once CD-R disc)
C0h	Interrupted Data Disc (Track at Once CD-R disc or CD-R disc of Packet)

If the disc is Blank Disc, Disc Style field is changeable. The Blank Disc means PCA, PMA and Program Area of a disc are unwritten.

If a disc is Blank Disc and Disc Style field is set to C0h by the MODE SELECT command before writing, Interrupted Writing is enabled. The Disc Type field, Number of Valid NRA field, Disc Identification field, Track Number of Track Information field in Disc Information Page and all fields in Track Information Page are available.

The initiator can not set the Disc Style field to 80h by the MODE SELECT command even if a disc is Blank Disc. The current value of the Disc Style field changes to 80h only when Audio Disc is inserted or when a Single-session disc which contains no data track is finalized by FINALIZE command with Next Session=00h.

If a disc is Blank Disc and Disc Style field is set to 00h by the MODE SELECT command before writing, Uninterrupted Writing is enabled. The Disc Type field, Number of Valid NRA field, Disc Identification field, Track Number of Track Information field in Disc Information Page and all fields in Track Information Page are invalid.

If Disc style is non-changeable and the disc is a interrupted written disc, the Disc Style field is set to 00h by the drive. If the disc is an Uninterrupted Written disc or conventional CD, the Disc Style field is set to 80h.

D2. Disc Type

If a disc is Blank Disc or a disc that Disc Identification Item of PMA and Program Area are both unwritten, Disc Type field is changeable.

If Disc Type field is changeable, the Disc Type field can be set to the following values by the MODE SELECT command.

Byte	Description
00h	CD-DA or CD-ROM Disc
10h	CD-I Disc
20h	CD-ROM XA Disc
other	Reserved

The value is written in Disc Identification Item of PMA of a disc. The Disc Identification Item is written at the same time with the first writing into Program Area.

D3. First Track Number

First Track Number field indicates the first user track on a disc. The value is expressed by Hex. from 01h to 63h.

If a disc is Blank Disc or a disc that First TOC Item of PMA and Program Area are both unwritten, First Track Number field is changeable.

First Track Number is changed to non-changeable by first writing of TOC Item in PMA or Program Area. First Track Number field indicates the minimum value that can be specified in Track Number of Track Information Page field.

D4. Last Track Number

Last Track Number field is always non-changeable.

Last Track Number field indicates the track number of last track (including Invisible Track) on a disc. If there is Invisible Track on a disc, the number of Last Track Number field indicates the track number of the Invisible Track.

If First Track Number field is changeable, Last Track Number field returns the same number as First Track Number field. The value of track number is expressed by Hex from 01h to 63h.

Last Track Number field indicates the maximum value that can be specified in Track Number of Track Information Page field.

D5. Number of Sessions

Number of Sessions field is always non-changeable.

Number of Sessions field returns the total number of existing session in a disc. Number of Sessions field includes the session which consists of only Invisible Track.

D6. Disc Application Code

Disc Application Code field is always non-changeable. Disc Application Code is written in blank disc by means of pregroove modulation and specifies application of the disc.

If the data is not written on a disc, this field returns "FF FF FF FF".

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Reserved							
1	1	Recording Power			Reserved			
2	0	Disc Application Code						
3	1	Reserved						

Recording Power:

A value for the recommended optimum recording power of the disc. This value is given for a laser wavelength of 785 nm and T = 25°C. The optimum recording power P_0 may depend on the wavelength. Each individual recorder might have a different laser wavelength. Therefore this encoded value can only be used as a first estimation of the exact value of P_0 . It can be used as a reference value P_{ref} for an accurate determination of P_0 in an Optimum Power Control procedure.

Recording Power	:	Optimum recording power in mW for $\lambda = 785 \text{ nm}$ and $T = 25^\circ\text{C}$
= 000	:	4.0 mW
= 001	:	4.4 mW
= 010	:	4.9 mW
= 011	:	5.4 mW
= 100	:	5.9 mW
= 101	:	6.6 mW
= 110	:	7.2 mW
= 111	:	8.0 mW

Disc Application Code:

This code distinguishes between discs used for different applications. The two main application categories are: 'Discs for unrestricted use', and 'Discs for restricted use'. Within the category 'Discs for restricted use', an additional encoding may be used for the identification of Special Disc Applications.

bit 6 = 0	:	Disc for restricted use.
bit 5..0 = 000000	:	General Purpose disc.
bit 5..0 = others	:	Special Purpose disc.
	:	Reserved for the encoding of Special Disc Applications.
bit 6 = 1	:	Disc for unrestricted use.
bit 5..0 = 000000	:	reserved.

D7. Last Possible Start Time of Lead Out

Last Possible Start Time of Lead Out field is always non-changeable. This value is written in blank disc by means of pregroove modulation and indicates capacity of the blank disc. If the data is not written on a disc, this field returns "FF FF FF FF".

Byte	Description
0	Reserved
1	Minutes (in hex)
2	Seconds (in hex)
3	Frame (in hex)

D8. Disc Status

Disc Status field is always non-changeable.

Disc Status field indicates the following two contents.

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Byte	Recordability	Reserved					Compatibility	

Disc Recordability:

Code	Description
00	Blank Disc
01	Recordable, Not Blank Disc
10	Unrecordable Disc
11	Reserved

Disc Compatibility:

Code	Sessions	Description
00	Single	This disc has only finalized single session
01	Single	This disc has only unfinalized single session.
10	Multi	This disc has all finalized sessions.
11	Multi	This disc has a unfinalized last session.
Other		Reserved

D9. Number of Valid NRA

Number of Valid NRA field is always non-changeable.

Number of Valid NRA field indicates how many NRA (Next Recordable Address) exist in a disc. The number indicated by this field is equal to the number of track with valid NRA.

The initiator gets all NRA and the track number of them by checking NRA field in Track Information Page of each track in descending order from Last Track Number.

D10. Track Number of Track Information Page

If Track Number of Track Information Page field is changed by the MODE SELECT command, the information of the track is called to Track Information Page.

The number which can be specified in Track Number of Track Information Page field by the MODE SELECT command is equal to or larger than First Track Number, and is equal to or smaller than Last Track Number.

If the number of First Track Number field and Last Track Number field are the same, Track Number of Track Information Page field is non-changeable. If they are not the same, it is changeable. The value is expressed by Hex.

D11. Post-Gap

If Post-Gap is set to 01h, the drive adds post-gap to each track automatically.

Post-Gap field is available only in case that a disc is recordable. (i.e. This field is changeable.)

If a disc is unrecordable, this field is invalid.

Byte	Description
00h	Without Post-Gap
01h	With Post-Gap

D12. Disc Identification Code

Disc Identification Code field is always non-changeable.

Disc Identification Code field returns the value of Disc Identification which is written in PMA of a disc. The data contains four bytes and the head of the bytes is 00h and three bytes are expressed by Hex. If the data is not written on a disc, this field returns "FF FF FF FF".

If Disc Identification is not written in PMA of a disc, Disc Identification is generated at random automatically by the drive when a disc is recognized. The Disc Identification is written at the same time with the Disc Type field.

4.4.1.4. CD-R Track Information Page (Page Code 23h)

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	PS	Reserved	Page Code (23h)					
1	Page length							
2	Reserved							
3	Track Number							
4	Data Form							
5	Write Method							
6	Session Number							
7	Track Status							
8 11	Starting LBA of the Track							
12 15	Next Recordable Address							
16 19	Capacity of Blank Area							
20 23	Fixed Packet Size							
24	Reserved							
25	Starting M Field							
26	Starting S Field							
27	Starting F Field							
28	Reserved							
29	Ending M Field							
30	Ending S Field							
31	Ending F Field							
32	Reserved							
33	Recordable Point M Field							
34	Recordable Point S Field							
35	Recordable Point F Field							

The initiator gets or sets the information of a track specified by Track Number of Track Information Page field in Disc Information Page using Track Information Page. The contents of Track Information Page is revised when a disc is changed, written or reserved.

Track Information Page is available only in case that Disc Style field of Disc Information Page is "Interrupted". (i.e. The disc is CD-R disc and Interrupted Writing.)

T1. Track Number

Track Number field indicates the track number of the track whose information is indicated in Track Information Page. The value is expressed by Hex. Track Number field is non-changeable.

T2. Data Form

Data Form field indicates the format of data which is written or will be written in the track.

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Byte	Copyright		Data Format					

Copyright:

Code	Description
00	Copy
01	Original with the copyright
10	Copyright Free
11	Reserved

Data Format:

Code	Description
00h	2ch Audio without pre-emphasis
01h	Reserved
02h	2ch Audio with pre-emphasis
03h	Reserved
04-0Fh	Reserved
10h	CD-ROM Mode-1
11h	CD-ROM Mode-2
12h	CD-ROM Mode-2 Form-1,2
13-1Fh	Reserved
21-FFh	Reserved

Data Form field is changeable if a specified track is Invisible Track or Empty Reserved Track.

The content of Copy bit of Subcode-Q is determined according to the content of the Copyright bits in Data Form field when the track is written.

The format of the track is determined according to the content of Data Form field.

If Data Form field is non-changeable, this field indicates the format of data written in the track.

If Data Form field is changeable and is changed by the MODE SELECT command, this field must follow the following combination.

Data Form 00h-03h (Audio Track):

Disc Type = 00h/10h

Data Form 10h (CD-ROM Mode-1 Track):

Disc Type = 00h

Data Form 11h (CD-ROM Yellow Mode-2 Track):

Disc Type = 00h

Data Form 12h (CD-ROM Mode-2 Form1, Form2):

Disc Type = 10h/20h

NOTE: If the Disc Type is 10h or 20h and the previous track is Audio Track (Data Form 00h-13h), the track except the first track cannot be specified as Data Track (Data Form 12h).

NOTE: If a track is Empty Reserved Track, the track must be Data Track.

NOTE: If a previous track of Empty Reserved Track is Data Track, the Mode of Empty Reserved Track must be the same as that of the previous track.

NOTE: If Empty Reserved Track is first track, the track must follow the following combinations.

Disc Type = 00h and Data Format = 10h/11h

or

Disc Type = 10h/20h and Data Format = 12h

T3. Write Method

Write Method field indicates how to write the data which is written or will be written in a track.

Write Method

Code	Description
00h	Track at Once Recording
01h	Packet Recording (Fixed Packet)
02h	Packet Recording (Variable Packet)
03-FFh	Reserved

Write Method field is changeable if a specified track is Invisible Track or Empty Reserved Track.

If Data Form is "Audio", only 00h (Track at Once) is available for Write Method field.

T4. Starting LBA of the Track

Starting LBA of the Track field indicates the head logical block address of user data area of the track. The address indicated by this field is equal to the head address of index=01 of the track. Starting LBA of the Track field and changeability of it are determined by the combination of format of previous track and the track. (i.e. the length of pause is different according to combination of format of the track and the previous track.) If the track is not Invisible Track or Empty Reserved Track, Starting LBA of the Track field is always non-changeable.

For the combination of format, see the following table.

Format of Previous Track	Format of This Track	Pause Length (sec.)	Changeability of this field
Lead-in	Audio	$2 \leq P \leq 3$	Changeable
Lead-in	Mode1	$P = 2$	Non-Changeable
Lead-in	Mode2	$P = 2$	Non-Changeable
Lead-in	Mode2, Form1,2	$P = 2$	Non-Changeable
Audio	Audio	$P \geq 2$	Changeable
Audio	Mode1	$P = 3$	Non-Changeable
Audio	Mode2	$P = 3$	Non-Changeable
Audio	Mode2, Form1,2	Impossible	Impossible
Mode1	Audio	$P \geq 2$	Changeable
Mode1	Mode1	$P = 2$	Non-Changeable
Mode1	Mode2	$P = 3$	Non-Changeable
Mode1	Mode2, Form1,2	Impossible	Impossible
Mode2	Audio	$P \geq 2$	Changeable
Mode2	Mode1	$P = 3$	Non-Changeable
Mode2	Mode2	$P = 2$	Non-Changeable
Mode2	Mode2, Form1,2	Impossible	Impossible
Mode2, Form1,2	Audio	$P \geq 2$	Changeable
Mode2, Form1,2	Mode1	Impossible	Impossible
Mode2, Form1,2	Mode2	Impossible	Impossible
Mode2, Form1,2	Mode2, Form1,2	$P = 2$	Non-Changeable

T5. NRA : Next Recordable Address

NRA field indicates the logical block address in the track where the initiator can write user data at this time. NRA field is always non-changeable.

If a track is Invisible Track or Empty Reserved Track, the value of NRA field is equal to the value of Starting LBA of the Track field. In case of Fixed Packet Recording, the value of NRA field is according to Orange Book Addressing Method-2.

In case of Packet Recording and Write Cache Enable, the value of NRA field is the value added the unwritten data length in the buffer to the address in which user data will be written.

If there is no writable area in the track (i.e. the track is Complete Track and Capacity of Blank Area field is zero), the NRA field is invalid.

If Track Status field is 05h or 06h, NRA field is invalid.

T6. Track Status

Track Status field indicates which track status the specified track is in.

Code	Description
00h	Complete Track
01h	Invisible Track
02h	Empty Reserved Track
03h	Partly Written Reserved Track
04h	Incomplete Track
05h	during Track at Once Recording for Reserved Track
06h	during Track at Once Recording for Invisible Track
07h	Reserved
08h	Damaged Track

For these descriptions except for 08h, see 4.1.2.2. Definition of track status and state transition.

The Damaged Track means the track where the drive is not able to write additionally because the last packet of the track is broken. The Damaged Track is able to be recovered by the Recover Track command. For details, see 4.3.2.7. RECOVER TRACK Command.

T7. Session Number

Session Number field indicates the session number of session which includes the track. This field is always non-changeable.

T8. Capacity of Blank Area

Capacity of Blank Area field is always non-changeable. This field indicates the number of unwritten blocks in the track. The number indicated by this field basically does not include Run-in, Run-out and Link Block which are inserted at every interrupted writing. The calculation methods of capacity indicated in this field are as follows.

Track at Once Recording

The case of Empty Reserved Track

Capacity = stop time - start LBA - postgap - 2

NOTE: "stop time" means the absolute time of end point of the track.

NOTE: Post-Gap and the last Run-out are not included.

The case of Invisible Track

Capacity = last possible time - start LBA - postgap - 2

NOTE: Last Possible Start Time of Lead-out is regarded as stop time.

NOTE: Post-Gap and the last Run-out are not included.

Variable Packet Recording

The case of Empty Reserved Track

* Write Cache Disable:

Capacity = stop time - start LBA - postgap - 2

* Write Cache Enable:

Capacity = stop time - start LBA - postgap - 2 - the length of unwritten data in buffer

NOTE: Post-gap and the last Run-out are not included.

The case of Partly Recorded Reserved Track

* Write Cache Disable:

Capacity = stop time - NRT - postgap - 2 - 4

* Write Cache Enable:

Capacity = stop time - NRT - postgap - 2 - 4 - the length of unwritten data in buffer

NOTE: NRT means absolute time of next recordable point of the track.

NOTE: Post-gap and the last Run-out are not included.

NOTE: Run-in of a packet that will be written is not included.

The case of Incomplete Track

* Write Cache Disable:

Capacity = last possible time - NRT - postgap - 2 - 4

* Write Cache Enable:

Capacity = last possible time - NRT - postgap - 2 - 4 - the length of unwritten data in buffer

NOTE: Last Possible Start Time of Lead-out is regarded as stop time.

NOTE: Post-gap and the last Run-out are not included.

NOTE: Run-in of a packet that will be written is not included.

The case of Invisible Track

* Write Cache Disable:

Capacity = last possible time - NRT - postgap - 2

* Write Cache Enable:

Capacity = last possible time - NRT - postgap - 2 - the length of unwritten data in buffer

NOTE: Last Possible Start Time of Lead-out is regarded as stop time.

NOTE: Post-gap and the last Run-out are not included.

Fixed Packet Write

The case of Empty Reserved Track

Write Cache Disable:

Capacity = (int) {(stop time - start LBA + 1 + 4)/(packet size + 7)} * packet size

Write Cache Enable:

Capacity = (int) {(stop time - start LBA + 1 + 4)/(packet size + 7)} * packet size - the length of unwritten data in buffer

NOTE: "+1+4" means the number of Link and Run-in blocks stuck in pre-gap.

NOTE: All Link, Run-in and Run-out are not included.

The case of Partly Recorded Reserved Track

* Write Cache Disable:

Capacity = (int) {(stop time - NRT)/(packet size + 7)} * packet size

* Write Cache Enable:

Capacity = (int) {(stop time - NRT)/(packet size + 7)} * packet size - the length of unwritten data in buffer

NOTE: All Link, Run-in and Run-out are not included.

The case of Incomplete Track

* Write Cache Disable:

Capacity = (int) {(last possible time - NRT)/(packet size + 7)} * packet size

* Write Cache Enable:

Capacity = (int) {(last possible time - NRT)/(packet size + 7)} * packet size - the length of unwritten data of buffer

NOTE: All Link, Run-in and Run-out are not included.

The case of Invisible Track

* Write Cache Disable:

Capacity = (int) {(last possible time - start LBA)/(packet size + 7)}
 * packet size

* Write Cache Enable:

Capacity = (int) {(last possible time - start LBA)/(packet size + 7)} * packet size - the length of unwritten data of
 buffer

NOTE: All Link, Run-in and Run-out are not included.

T9. Fixed Packet Size

Fixed Packet Size field is available if Write Method is Fixed Packet Recording. This field indicates the size of user data of each Packet which is written or will be written in the track.

Fixed Packet Size field is changeable if the track is Invisible Track or Empty Reserved Track.

The initiator can not set the value of Fixed Packet Size field to zero.

T10. Starting M Field

T11. Starting S Field

T12. Starting F Field

The above three fields indicate the value that is changed the Starting LBA of the Track into MSF address. These fields are always non-changeable.

T13. Ending M Field

T14. Ending S Field

T15. Ending F Field

The above three fields indicate the absolute time of end point of the track. If the track is Invisible Track or Incomplete Track, these fields are invalid. These fields are always non-changeable.

T16. Recordable Point M Field

T17. Recordable Point S Field

T18. Recordable Point F Field

The above three fields indicate the value that is changed the Next Recordable Address of the track into MSF address. If Next Recordable Address field of the track is invalid, these fields are also invalid. These fields are always non-changeable.

4.4.1.5. Drive Speed Page (Page Code 31h)

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Reserved		Page Code (31h)					
1	Parameter Length (02h)							
2	Speed							
3	Reserved							

The Speed field provides a means for the initiator to set and retrieve the spindle speed when accessing data areas.

Table 4-9 Speed Field

Value	Description
00h	Normal Speed
01h	Double Speed
Other value	Reserved

The speed setting is only applicable when reading data areas. The target will automatically switch to normal speed when playing audio tracks and will switch back to the speed setting when accessing data.

The default setting is double speed. The drive will switch to the default setting after a reset.

The initiator can set the speed even if there is no disc inside the drive. The speed setting should not be changed by a disc ejection/insertion or playing audio tracks.

4.5. Sense Keys and Additional Sense Codes

4.5.1. Sense Keys

The following table lists the sense keys reported in Byte 2 of the REQUEST SENSE data.

Table 4-10 Sense Key

Sense Key	Description
00h	No Sense
01h	Recovered Error
02h	Not Ready
03h	Medium Error
04h	Hardware Error
05h	Illegal Request
06h	Unit Attention
0Bh	Aborted Command

4.5.2. Additional Sense Codes & Additional Sense code Qualifier

The following table lists the supported additional sense codes and additional sense code qualifier reported in Byte 12 and 13 of the REQUEST SENSE data.

Table 4-11 Additional Sense Codes

ASC	ASCQ	Key	Description
00	00	00	NO ADDITIONAL SENSE INFORMATION
00	14	03	AUDIO PLAY OPERATION STOPPED DUE TO ERROR
02	00	03	NO SEEK COMPLETE
04	00	02	LOGICAL UNIT NOT READY, CAUSE NOT REPORTABLE
04	01	02	LOGICAL UNIT IS IN PROGRESS OF BECOMING READY. (TABLE-OF CONTENTS READ IN PROGRESS)
08	00	04	LOGICAL UNIT COMMUNICATION FAILURE
09	01	04	TRACKING SERVO FAILURE
09	02	04	FOCUS SERVO FAILURE
09	03	04	SPINDLE SERVO FAILURE
11	05	03	L-EC UNCORRECTABLE ERROR (L-EC CODES PRESENT AND L-EC ON)
11	06	03	CIRC UNRECOVERED ERROR (L-EC UNAVAILABLE OR OFF)
11	0D	03	SUBCODE ECC UNRECOVERED ERROR
17	01	01	RECOVERED DATA WITH RETRIES
18	01	01	RECOVERED DATA WITH ERROR CORRECTION&RETRIES APPLIED
18	04	01	RECOVERED DATA WITH L-EC
20	00	05	INVALID COMMAND OPERATION CODE
21	00	05	LOGICAL BLOCK ADDRESS OUT OF RANGE
24	00	05	INVALID FIELD IN CDB
25	00	05	LOGICAL UNIT NOT SUPPORTED
26	00	05	INVALID FIELD IN PARAMETER LIST
28	00	06	NOT READY TO READY TRANSITION
29	00	06	POWER ON, RESET OR BUS DEVICE RESET OCCURRED
2A	01	06	MODE PARAMETER CHANGED
3A	00	02	MEDIUM NOT PRESENT
40	00	04	DIAGNOSTIC FAILURE ON COMPONENT 0 (ROM FAILURE)
40	01	04	DIAGNOSTIC FAILURE ON COMPONENT 1 (RAM FAILURE)
40	02	04	DIAGNOSTIC FAILURE ON COMPONENT 2 (BUFFER FAILURE)
40	03	04	DIAGNOSTIC FAILURE ON COMPONENT 3 (INTERNAL BUS FAILURE)
43	00	0B	MESSAGE ERROR
44	00	04	INTERNAL TARGET FAILURE
45	00	0B	SELECT/RESELECT FAILURE
48	00	0B	INITIATOR DETECTED ERROR MESSAGE RECEIVED
49	00	0B	INVALID MESSAGE ERROR
4E	00	0B	OVERLAPPED COMMAND ATTEMPTED
47	00	04	SCSI PARITY ERROR
53	00	02	MEDIA LOAD/EJECT FAILED
53	02	05	MEDIUM REMOVAL PREVENT
57	00	02	UNABLE TO RECOVER TABLE-OF-CONTENTS
63	00	05	END OF USER AREA ENCOUNTERED ON THIS TRACK
64	00	05	ILLEGAL MODE FOR THIS TRACK

Additional Sense Codes

ASC	ASCQ	Key	Description
80	00	06	WRITE COMPLETE
81	00	05	LOGICAL UNIT IS RESERVED
85	00	05	AUDIO ADDRESS NOT VALID
88	00	05	ILLEGAL CUE SHEET (The Cue Sheet Error Code is set in Additional Sense Bytes, See 4.5.3 and Appendix A.)
89	00	05	INAPPROPRIATE COMMAND
B6	00	04	MEDIA LOAD MECHANISM FAILED
B9	00	0B	AUDIO PLAY OPERATION ABORTED
BF	00	05	BUFFER OVERFLOW FOR READ ALL SUBCODES COMMAND
C0	00	05	UNRECORDABLE DISC
C1	00	05	ILLEGAL TRACK STATUS
C2	00	05	RESERVED TRACK PRESENT
C3	00	05	BUFFER DATA SIZE ERROR
C4	00	05	ILLEGAL RESERVE LENGTH FOR RESERVE TRACK COMMAND
C4	01	05	ILLEGAL DATA FORM FOR RESERVE TRACK COMMAND
C4	02	05	UNABLE TO RESERVE TRACK, BECAUSE TRACK MODE HAS BEEN CHANGED
C5	00	06	BUFFER ERROR DURING AT ONCE RECORDING
C6	01	05	UNWRITTEN AREA ENCOUNTERED
C6	02	05	LINK BLOCKS ENCOUNTERED
C6	03	05	NONEXISTENT BLOCK ENCOUNTERED
C7	00	04	DISC STYLE MISMATCH
C8	00	05	NO TABLE-OF-CONTENTS
C9	00	05	ILLEGAL BLOCK LENGTH FOR WRITE COMMAND
CA	00	03	POWER CALIBRATION ERROR
CB	00	03	WRITE ERROR
CB	00	06	WRITE ERROR DURING AT ONCE RECORDING
CB	01	03	WRITE ERROR TRACK RECOVERED
CC	00	05	NOT ENOUGH SPACE
CD	00	05	NO TRACK PRESENT TO FINALIZE
CE	00	05	UNRECOVERABLE TRACK DISCRIPTER ENCOUNTERED
CF	00	05	DAMAGED TRACK PRESENT
D0	00	05	PMA AREA FULL
D1	00	05	PCA AREA FULL
D2	00	05	UNRECOVERABLE DAMAGED TRACK CAUSE TOO SMALL WRITABLE AREA

4.5.3. Additional Sense Bytes

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Drive Status							
1	Additional Drive Status							
2								
3								
4								
5								
6								
7								

Drive Status byte discriminates and indicates the following four status.

Table 4-12 Drive Status

Code	Description of status
00h	Ready (Normal) status
01h	No Disc status
02h	Write status
03h	Audio Play status

Additional Drive Status field indicates internal status code for drive maintenance.

4.6. Cue Sheet

The Cue Sheet is information to specify a format of CD which will be made, and must be sent to the drive by WRITE START command before Writer begins to write data on the CD.

4.6.1 CUE SHEET FORMAT

The Cue Sheet format is as follows:

Table 4-13 Cue Sheet format (Example)

Byte Number	Cue Sheet Data
0	Information of a disc location (m lines)
:	
:	
(m-1)* 8	

4.6.1.1 Information of the disc location

The drive writes a disc according to this information.

This information defines the following matters;

- * generation of Subcode P and Q channel.
- * format and processing of the data transferred by the WRITE CONTINUE command

**Table 4-14 Information of the disc location
(Example)**

Byte Number (Hex.)	Cue Sheet Data							
	CONT /ADR	TNO	X	DATA FORM	ZERO	ABSOLUTE TIME		
00(Lead-in)	01	00	00 *1	00 *6	00	00 *1	00 *4	00 *1
08(TNO:01)	01	01	00 *1	00	00	00 *1	00 *1	00 *1
10(TNO:01) *2	01	01	01	01	00	00	02	00
18(TNO:02)	01	02	00	01	00	07	29	71
20(TNO:02)	01	02	01	01	00	07	31	71
28(TNO:03)	01	03	01	01	00	14	18	03
30(TNO:04) *5	41	04	00	10	00	19	06	62
38(TNO:04)	41	04	01	11	00	19	09	62
40(TNO:04) *5	41	05	00	18	00	27	37	10
48(TNO:05)	41	05	01	19	00	27	40	10
50(TNO:06)	01	06	00	00	80	38	53	23
58(TNO:06)	01	06	01	01	80	38	55	23
60(Lead-out)	01	AA	01 *3	00 *6	00	56	37	46

All numbers are Hex.

- *1 Always zero
- *2 The first information track on a disc is preceded by a pause encoding of 2-3 seconds. (If the first track is a Data track, this track does not contain a pre-gap, but always starts with a "pause" of 2 seconds.)
- *3 Always 01h
- *4 Disc Type (See 8) below)
- *5 Pre-gap (See 9) below)
- *6 For Lead-in and Lead-out area DATA FORM of Data Size=0 must be selected.

This information is composed of some data units of 8 bytes(1 line).

This information is consists of three parts. The first part is described about Lead-in area and contains only one data unit. The second part is about Program area and contains some data units. The last part is about Lead-out area and contains one or some data units. The data units about Program area and Lead-out area are lined in Absolute Time order.

The each data unit of Program area and Lead-out area indicates that the value of each field (CONTROL, TNO, X, DATA FORM or ZERO) changes from the time shown in ABSOLUTE TIME field.

Example:

Cue Sheet Data							
CONT /ADR	TNO	X	DATA FORM	ZERO	ABSOLUTE TIME		
					Min	Sec	Frame
01	02	01	C1	00	07	31	71
01	03	01	C1	00	14	18	03

The above data unit indicates that the value of TNO changes from 02 to 03 when ABSOLUTE TIME is 14:18:03.

1) CONTROL(upper 4bits)

The CONTROL field contains 4 flag bits to define the kind of information in a track.

00x0: 2 audio channels without pre-emphasis
 10x0: 4 audio channels without pre-emphasis
 00x1: 2 audio channels with pre-emphasis of 50/15 micro sec.
 10x1: 4 audio channels with pre-emphasis of 50/15 micro sec.
 01x0: Data track
 xx0x: digital copy prohibited
 xx1x: digital copy permitted

The bits of the CONTROL field (except for the copy bit) can be changed during an actual pause (X=00) of at least 2 seconds and during Lead-in area only.

2) ADDRESS(lower 4bits)

The ADDRESS is always 1h in the Information Of The Disc Location.

3) TNO

TNO indicates track number expressed in 2 digits BCD.
 Each track has a minimum length of 4 seconds, not including the pause length preceding the track.

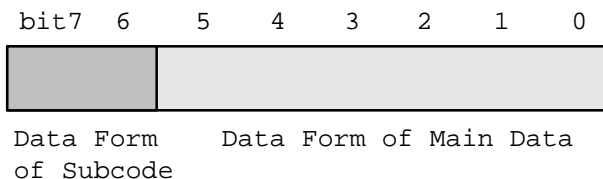
4) X

X indicates index number expressed in 2 digits BCD. The drive supports only 00h~99h.

5) DATA FORM

The Data Form consists of two fields as follows;

Figure 4-4 Data Form byte



5)-1 DATA FORM OF MAIN DATA

The followings are available as the data format.

- a. Music
- b. CD-ROM mode 0
- c. CD-ROM mode 1
- d. CD-ROM mode 2
- e. CD-ROM XA, CD-I

The DATA FORM OF MAIN DATA field specifies the format, such as five types above, of the main data stored in the inner buffer by WRITE CONTINUE command to write on the disc.

For Lead-in and Lead-out area DATA FORM of Data Size=0 must be selected.

a. Music**Figure 4-5 CD (music)**

Data Form	Data of One Frame	Data Size
00h	0	0
01h	2352	2352

The music data format is as follows;

- 1 Second = 75 Frames
- 1 Frame = 588 Samples
- 1 Sample = 4 bytes (16bits L,Rch)

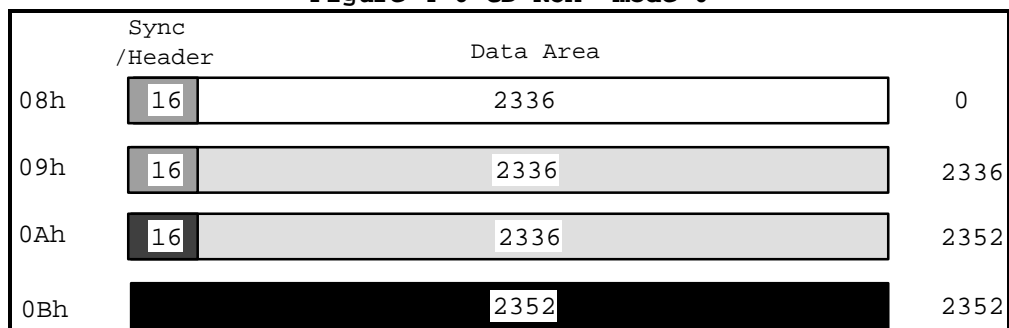
Table 4-15 Music Data format (1 Sample)

byte	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
n*4+0 (L ch)	L7	L6	L5	L4	L3	L2	L1	L0
n*4+1 (L ch)	L15	L14	L13	L12	L11	L10	L9	L8
n*4+2 (R ch)	R7	R6	R5	R4	R3	R2	R1	R0
n*4+3 (R ch)	R15	R14	R13	R12	R11	R10	R9	R8


n = 0,1, .. ,587


b. CD-ROM mode 0


Figure 4-6 CD-ROM mode 0





Data Size: The initiator should send the data with this data size to generate one frame to the drive.

 Generate Zero Data: The drive generates zero data in this area. The initiator need not send the data for this area.

 Read Buffer: The drive reads the data from inner buffer in which the data sent from the initiator by WRITE CONTINUE command has been saved.

 Generate Data: The drive generates the data in this area. The initiator need not send the data for this area.

 Ignore Buffer: The drive receives the data for this area from the initiator by WRITE CONTINUE command. However Encoder ignores the data and generates a data for this area.

 CD-DA Format: The initiator sends the data encoded to CD-DA format(audio) by WRITE CONTINUE command.

c. CD-ROM mode 1

Figure 4-7 CD-ROM mode 1


Data Form	Data of One Frame			Data Size
	Sync /Header	Data Area	EDC/ECC Area	
10h	16	2048	288	0
11h	16	2048	288	2048
12h	16	2048	288	2336
13h	16	2048	288	2352
14h		2352		2352


d. CD-ROM mode 2


Figure 4-8 CD-ROM mode 2


	Sync /Header	Data Area	
18h	16	2336	0
19h	16	2336	2336
1Ah	16	2336	2352
1Bh		2352	2352


Data Size: The initiator should send the data with this data size to generate one frame to the drive.

 Generate Zero Data: The drive generates zero data in this area. The initiator need not send the data for this area.

 Read Buffer: The drive reads the data from inner buffer in which the data sent from the initiator by WRITE CONTINUE command has been saved.

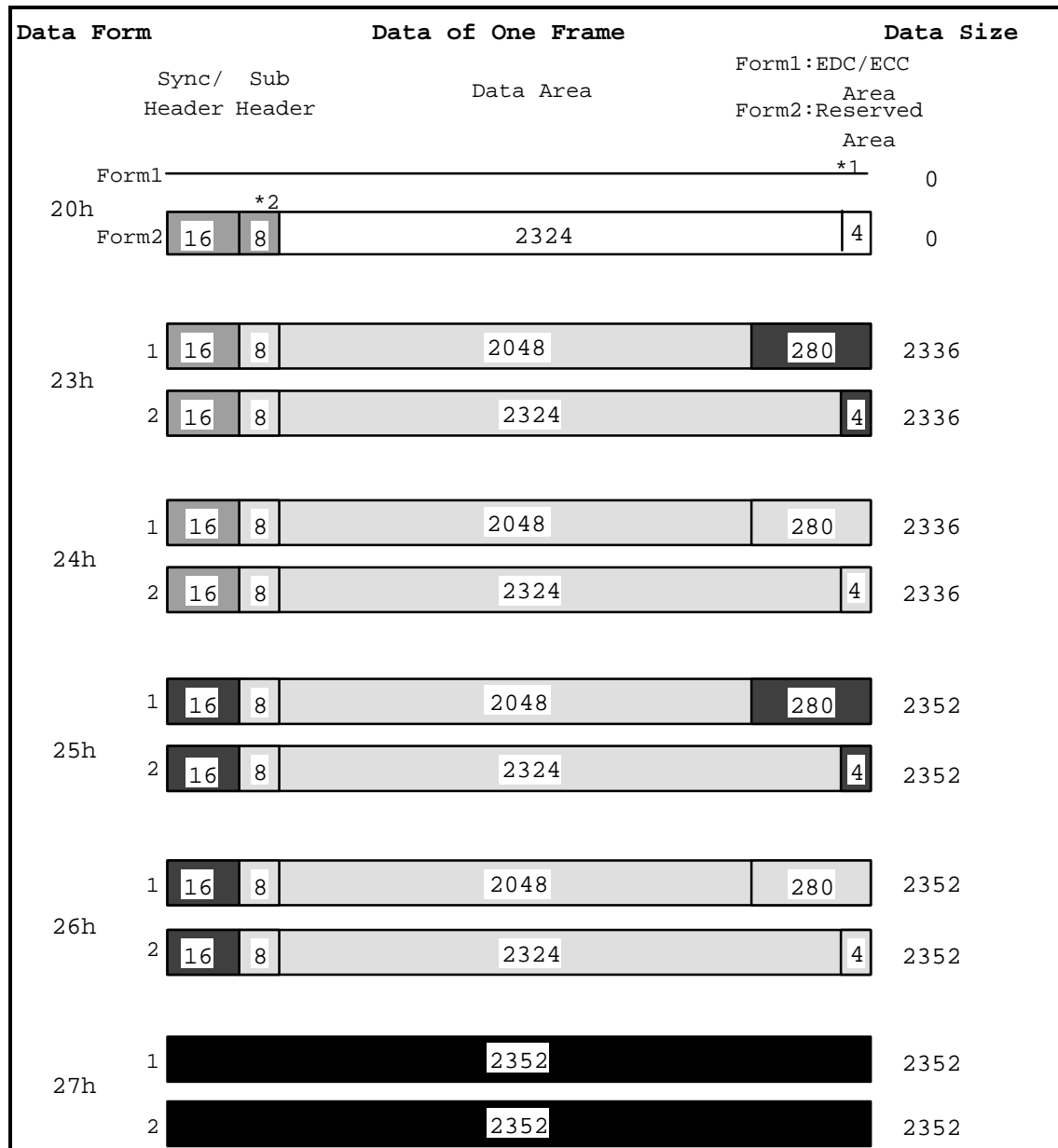
 Generate Data: The drive generates the data in this area. The initiator need not send the data for this area.

 Ignore Buffer: The drive receives the data for this area from the initiator by WRITE CONTINUE command. However Encoder ignores the data and generates a data for this area.

 CD-DA Format: The initiator sends the data encoded to CD-DA format(audio) by WRITE CONTINUE command.

e. CD-ROM XA, CD-I

Figure 4-9 CD-ROM XA, CD-I



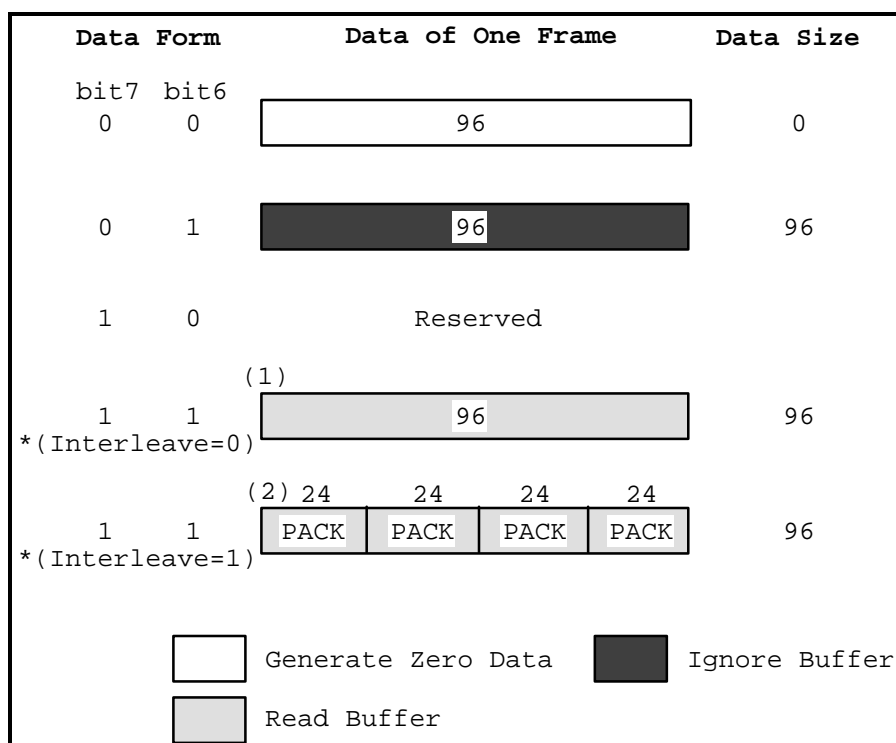
- *1 The drive generates form-2 data only.
- *2 Sub Header = 0000 2000 0000 2000[Hex.] only.
- *3 In this case, EDC/ECC area length of the data sent from the initiator is 276 bytes.

Reserved Area: The Reserved Area contains 4bytes that are reserved for quality control during the disc production process. In case of Generate Zero, the drive generates zero data of 4bytes for this area.

5)-2 DATA FORM OF SUBCODE

The DATA FORM OF SUBCODE field specifies the format of the subcode data stored in the inner buffer by WRITE CONTINUE command to write on the disc.

Figure 4-10 Data Form of Subcode



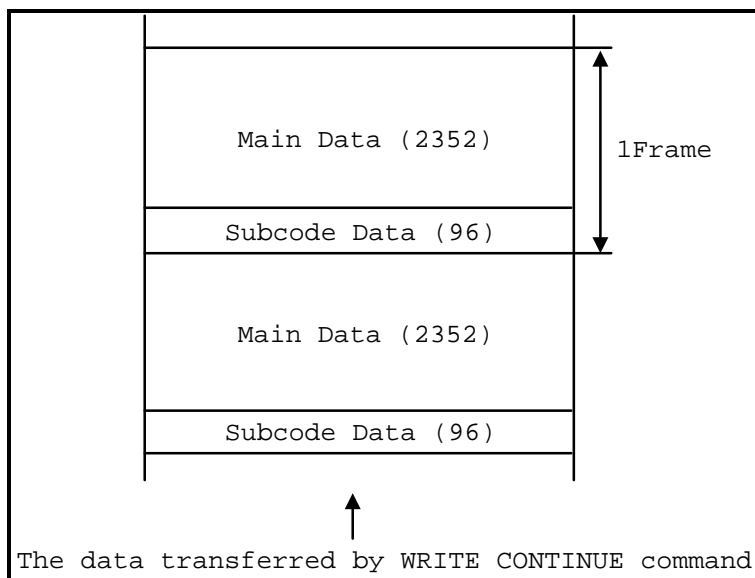
(1) The drive encodes the subcode data as the data has already calculated ECC and performed Interleaving.

(2) The drive calculates and overwrites ECC, and performs Interleaving for each PACK.

* See Mastering Information Page.

The subcode data is placed at between the Main Data of one frame.

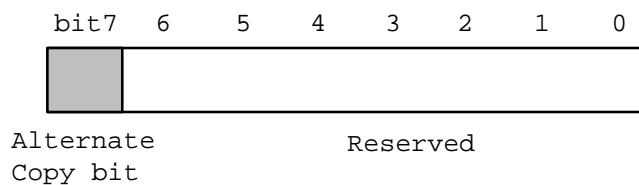
**Figure 4-11 Location of Subcode Data
(Example; Data form=C1)**



6) ZERO

The Alternate Copy bit of 1 indicates that Copy bit of CONTROL field alternates for Serial Copy Management System.
The other 7 bits (Reserved) are zero.

Figure 4-12 ZERO Byte



7) ABSOLUTE TIME

The time shown at Min, Sec, and Frame gives the changing point of the CONTROL, TNO, X, DATA FORM or ZERO field. These values are given in absolute time scale. ABSOLUTE TIME is a running time on the disc expressed in 6 digits BCD. One second is subdivided into 75 frames (running from 00 to 74).

8) Disc Type

The Disc Type is used for the identification of the type of disc.

00h : CD-DA(audio) or CD-ROM disc
10h : CD-I disc
20h : CD-ROM XA disc

9) Pre-gap

If a Data track is preceded by an other kind of track (such as an audio track) or if the mode number of CD-ROM changes, this Data track starts with a pre-gap. A pre-gap is placed at the head of a Data track, also is belonging to the Data track. A pre-gap does not contain actual user data. The pre-gap is encoded as "pause".

A pre-gap is divided into two parts. The first part of the pre-gap has minimum 1 second data, and it is encoded according to the data structure of previous track. The second part has a minimum 2 seconds data, and this data track is encoded according to the same data structure as the other parts.

Notice the following points when making a disc that has Pre-gap.

If a initiator selects a Cue Sheet Option Code that "Modify Pre-gap" is "Yes", the drive behaves as follows;

There is no need a mark to point the area of pre-gap, but need a minimum 3 seconds' "pause" in the Cue Sheet.

When the drive receives Cue Sheet, it finds a area for pre-gap in the Cue Sheet automatically. Then this pre-gap is divided into two parts (the first part and second part). The changing point of Data Form that is placed at the head of first part must be moved on the head of second part. (It means that Cue Sheet is modified.) Then, the length of first part is settled 1 second.

At this time, it is important that the changing point of Data Form shifts 1 second back. It means that the data of the previous track increase 1 second, but that the data of the track decrease 1 second. The initiator must send the data according to the Cue Sheet after the movement of Data Form.

If a initiator selects a Cue Sheet Option Code that "Modify Pre-gap" is "No", the drive does not behave as above. Therefore, the initiator must send a Cue Sheet in which Pre-gap is described correctly to the drive.

For example, the Pre-gap of TNO:04 in table 3-2 is described as follows;

Byte Number (Hex.)	Cue Sheet Data							
	CONT /ADR	TNO	X	DATA FORM	ZERO	ABSOLUTE TIME		
						Min	Sec	Fram e
30(TNO:04)	41	04	00	01	00	19	06	62
38(TNO:04)	41	04	00	10	00	19	07	62
40(TNO:04)	41	04	01	11	00	19	09	62

10) Post-gap

If a Data track is followed by an other kind of track (such as an audio track), this Data track ends with a post-gap. A post-gap is placed at the end of a Data track, and is belonging to the Data Track. A post-gap does not contain actual user data. The minimum length of post-gap is 2 seconds. The drive does not perform any action for Post-gap.

4.6.1.2. Catalog Number

The Catalog Number indicates a catalog number of a disc. The number uses UPC/EAN-code (BAR coding). If no catalog number is used, it must be deleted. The format is as follows;

Table 4-16 Catalog Number (N1..N13)

CONT/ADR	Catalog Number						
byte0	byte1	byte2	byte3	byte4	byte5	byte6	byte7
02h	N1 N2	N3 N4	N5 N6	N7 N8	N9 N10	N11 N12	N13 0h

CONTROL : 4bits are zero.

ADDRESS : 0010

Catalog Number: 13digits BCD

4.6.1.3. ISRC

ISRC (International Standard Recording Code) is a peculiar code that is given to music track. If no ISRC is used, it must be deleted. If a track has no ISRC, it is not written in the Sheet. The track number must be in small order.

Table 4-17 ISRC (Example)

Byte Number	CONT/ADR	TNO	ZERO	ISRC				
	byte0	byte1	byte2	byte3	byte4	byte5	byte6	byte7
0	03h	01h	00h	ISRC of track1 (I1..I5)				
8	03h	01h	00h	ISRC of track1 (I6..I12)				
16	03h	02h	00h	ISRC of track2 (I1..I5)				
24	03h	02h	00h	ISRC of track2 (I6..I12)				
32	03h	04h	00h	ISRC of track4 (I1..I5)				
40	03h	04h	00h	ISRC of track4 (I6..I12)				
:	:	:	:	:				
:	:	:	:	:				
:	:	:	:	:				

CONTROL: 4bits are zero.

ADDRESS: 0010

TNO : track number (in small order)

ZERO : 8bits are zero.

Table 4-18 ISRC (I1..I12)

byte3	byte4	byte5	byte6	byte7
I1	I2	I3	I4	I5
00h	I6, I7	I8, I9	I10, I11	I12, 0h

12 letters ISRC

(On the Cue Sheet, I1-I5 must be described by ASCII code, and I6-I12 must be described by BCD.)

I1-I2 : Country Code

I3-I5 : Owner Code

I6-I7 : Year of recording

I8-I12 : Serial Number

4.6.2. CUE SHEET FORMAT FOR MASTER DISC

In case of making a Master Disc, the drive needs Cue Sheet for Master Disc. The Cue Sheet format for making Master Disc is as follows;

**Table 4-19 Cue Sheet format for Master Disc
(Example)**

Byte Number	Cue Sheet Data
0 : : (m-1)* 8	Information of a disc location (m lines) : :
m* 8	Catalog number (N1..N13)
(m+1)* 8 : (m+n)* 8	ISRC (n lines) :
(m+n+1)* 8 : :	Disc Information :

The Information of a disc location, Catalog number and ISRC of Cue Sheet format for Master Disc are the same as that of Cue Sheet format. (See 4.6.1)

4.6.2.1. Disc Information

The user information of the disc is written in Disc Information area. (It must not be deleted.) Disc Information must be placed at the end of Cue Sheet.

Table 4-20 Disc Information

byte0	byte1	byte2	byte3	byte4	byte5	byte6	byte7
0Fh	00h	Data Length	FFh	FFh	FFh	FFh	FFh
Disc Name (0..7 byte)							
Disc Name (8..15 byte)							
Disc Name (16..23 byte)							
Disc Name (24..31 byte)							
Producer Name (0..7 byte)							
Producer Name (8..15 byte)							
Producer Name (16..23 byte)							
Producer Name (24..31 byte)							
Copyright Holder Name (0..7 byte)							
Copyright Holder Name (8..15 byte)							
Copyright Holder Name (16..23 byte)							
Copyright Holder Name (24..31 byte)							
Disc Creation Date							

1) Data Length

The Data Length indicates the data size except first data unit of Disc Information. The value is indicated in bytes. The Data Length must be a multiples of 8.

2) Disc Name

The Disc Name is written by ASCII code. The blank must be 20H.

3) Producer Name

The Producer Name is written by ASCII code. The blank must be 20h.

4) Copyright Holder Name

The Copyright Holder Name is written by ASCII code. The blank must be 20h.

5) Disc Creation Date

The Disc Creation Date is written by the following form. Figures are always input by ASCII code.

**Table 4-21 Disc Creation Date
(Example)**

Year				Month		Day	
31h(1)	39h(9)	39h(9)	34h(4)	30h(0)	32h(2)	32h(2)	39h(9)

Disc Creation Date : 1994.2.29

4.6.3. MASTER CUE SHEET FORMAT

The Master Cue Sheet is recorded in a Master CD and used for Mastering.
The Master Cue Sheet format is as follows;

**Table 4-22 The format of Master Cue Sheet
(Example)**

byte0	byte1	byte2	byte3	byte4	byte5	byte6	byte7
00h	FFh	FFh	00h	00h	00h	00h	00h
Subcode-P Cue Sheet							
Subcode-Q Cue Sheet							
(Catalog Number Sheet)							
(ISRC Sheet)							

The Master Cue Sheet consists of some Sheets.

4.6.3.1. The format of Subcode-P Cue Sheet

The Starting Time and Last Time of Start flag is described in Subcode-P Cue Sheet at Absolute Time in Subcode Q channel as follows.

**Table 4-23 The format of Subcode-P Cue Sheet
(In case a disc has n tracks)**

Byte Number	Starting Time of Start flag				Last Time of Start flag			
	ZERO(00)	MIN	SEC	FRAME	ZERO(00)	MIN	SEC	FRAME
	byte0	byte1	byte2	byte3	byte4	byte5	byte6	byte7
0	Start flag of First Track							
8	Start flag of Second Track							
:	:							
:	:							
:	:							
(n-1)*8	Start flag of Last Track							
n*8	Start flag of Lead-out							
(n+1)*8	Starting Time of switching in 2Hz				00h	00h	00h	00h

4.6.3.2. The format of Subcode-Q Cue Sheet

The Subcode-Q Cue Sheet is as follows.

**Table 4-24 The format of Subcode-Q Cue Sheet
(Example)**

Byte Number (Hex.)	Cue Sheet Data							
	CONT /ADR	TNO	X	DATA FORM	ZERO	ABSOLUTE Min Sec		TIME Frame
00(Lead-in)	01	00	00 *1	00	00	00	*1	00 *1
08(TNO:01)	01	01	00 *1	00	00	00	*1	00 *1
10(TNO:01) *2	01	01	01	00	00	00	02	00
18(TNO:02)	01	02	00	00	00	07	29	71
20(TNO:02)	01	02	01	00	00	07	31	71
28(TNO:03)	01	03	01	00	00	14	18	03
30(TNO:04) *5	41	04	00	00	00	19	06	62
38(TNO:04) *6	41	04	00	02	00	19	07	62
40(TNO:04)	41	04	01	02	00	19	09	62
48(TNO:05) *5	41	05	00	02	00	27	37	10
50(TNO:05) *6	41	05	00	03	00	27	38	10
58(TNO:05)	41	05	01	03	00	27	40	10
60(TNO:06)	01	06	00	00	00	38	53	23
68(TNO:06)	01	06	01	00	00	38	55	23
70(TNO:06)	01	06	02	00	00	45	12	42
78(TNO:06)	01	06	03	00	00	48	33	09
80(TNO:06)	01	06	04	00	00	52	47	59
88(Lead-out)	01	AA	01 *3	00	00	56	37	46

All numbers are Hex.

*1 Always zero

*2 The first information track on a disc is preceded by a pause encoding of 2-3 seconds. (If the first track is a Data track, this track does not contain a pre-gap, but always starts with a "pause" of 2 seconds.)

*3 Always 01h

*4 Disc Type [See 8) below]

*5 Pre-gap [See the first part of pre-gap in 9) below]

*6 Pre-gap [See the second part of pre-gap in 9) below]

This information is composed of some data units of 8 bytes(1 line). This information is consists of three parts. The first part is described about Lead-in area and contains only one data unit. The second part is about Program area and contains some data units. The last part is about Lead-out area and contains one or some data units. The data units about Program area and Lead-out area are lined in Absolute Time order.

1) CONTROL (upper 4bits)

The CONTROL field contains 4 flag bits to define the kind of information in a track.

00x0: 2 audio channels without pre-emphasis

10x0: 4 audio channels without pre-emphasis

00x1: 2 audio channels with pre-emphasis of 50/15 micro sec.

10x1: 4 audio channels with pre-emphasis of 50/15 micro sec.

01x0: Data track

xx0x: digital copy prohibited

xx1x: digital copy permitted

The bits of the CONTROL field (except for the copy bit) can change during an actual pause of at least 2 seconds and during Lead-in area only.

2) ADDRESS (lower 4bits)

The ADDRESS is always 1h in Subcode-Q Cue Sheet.

3) TNO

TNO indicates track number expressed in 2 digits BCD.

4) X

X indicates index number expressed in 2 digits BCD.

5) DATA FORM

DATA FORM indicates the Data format of the part that starts at the point shown in ABSOLUTE TIME field.

00h : CD-DA (audio)

01h : CD-ROM mode 0

02h : CD-ROM mode 1

03h : CD-ROM mode 2

04h : CD-ROM mode 2 form 1 and form 2

6) ZERO

These 8 bits are zero.

7) ABSOLUTE TIME

The time shown at Min, Sec, and Frame gives the changing point of the CONTROL, TNO, X, DATA FORM or ZERO field. These values are given in absolute time scale. ABSOLUTE TIME is a running time on the disc expressed in 6 digits BCD. One second is subdivided into 75 frames (running from 00 to 74).

8) Disc Type

The Disc Type is used for the identification of the type of disc

00h : CD-DA(audio) or CD-ROM

10h : CD-I disc

20h : CD-ROM XA disc

9) Pre-gap

If a Data track is preceded by an other kind of track (such as an audio track) or if the mode number of CD-ROM changes, this Data track starts with a pre-gap. A pre-gap is placed at the first area of Data track also is belonging to the Data track. A pre-gap does not contain actual user data. The pre-gap must be encoded as "pause".

A pre-gap is divided into two parts. The first part of the pre-gap has minimum 1 second data, and it is encoded according to the data structure of previous track. The second part has a minimum 2 seconds data, and this data track is encoded according to the same data structure as the other parts.

10) Post-gap

If a Data track is followed by an other kind of track (such as an audio track), this Data track ends with a post-gap. A post-gap is placed at the end of a Data track, and is belonging to the Data Track. A post-gap does not contain actual user data. The minimum length of post-gap is 2 seconds.

4.6.3.3. The format of Catalog Number Sheet

The Catalog Number indicates a catalog number of a disc. The number uses UPC/EAN-code (BAR coding). If no Catalog Number is used, this Sheet does not exist. The format is as follows;

Table 4-25 The format of Catalog Number Sheet

CONT/ADR	Catalog Number						
byte0	byte1	byte2	byte3	byte4	byte5	byte6	byte7
02h	N1 N2	N3 N4	N5 N6	N7 N8	N9 N10	N11 N12	N13 0h

CONTROL : 4bits are zero.

ADDRESS : 0010

Catalog Number: 13digits BCD

4.6.3.4. The format of ISRC Sheet

ISRC (International Standard Recording code) is a peculiar code that is given to music track. If no ISRC is used, this Sheet does not exist. Also, if a track has no ISRC, it is not written in the Sheet. The track number must be in small order.

**Table 4-26 The format of ISRC Sheet
(Example)**

Byte Number	CONT/ADR	TNO	ZERO		ISRC			
	byte0	byte1	byte2	byte3	byte4	byte5	byte6	byte7
0	03h	01h	00h	00h	ISRC of track1 (I1..I5)			
8	03h	01h	00h	00h	ISRC of track1 (I6..I12)			
16	03h	02h	00h	00h	ISRC of track2 (I1..I5)			
24	03h	02h	00h	00h	ISRC of track2 (I6..I12)			
32	03h	04h	00h	00h	ISRC of track4 (I1..I5)			
40	03h	04h	00h	00h	ISRC of track4 (I6..I12)			
:	:	:	:	:	:			
:	:	:	:	:	:			
:	:	:	:	:	:			

The line of byte1 : put the track number

Table 4-27 ISRC (I1..I5)

byte number	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
4	I1						(MSB)	I2
5	I2			(LSB)	(MSB)	I3		
6	I3	(LSB)	I4					
7	I5						0h	0h

Table 4-28 ISRC (I6..I12)

byte number	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
4	I6				I7			
5	I8				I9			
6	I10				I11			
7	I12				0h	0h	0h	0h

12 letters ISRC

I1-I2 : Country Code
 I3-I5 : Owner Code
 I6-I7 : Year of recording
 I8-I9 : Serial Number

APPENDIX A Cue Sheet Error Code

00010000h : Illegal Cue Sheet Size
0002xxxxh : Illegal CONTROL
0003xxxxh : Illegal ADDRESS
0004xxxxh : Illegal TNO
0005xxxxh : Illegal X
0006xxxxh : Illegal DATA FORM
0007xxxxh : Illegal ABSOLUTE TIME
0008xxxxh : No Pause Error at Pre-gap
0009xxxxh : Short Pause Error at Pre-gap
000Axxxxh : Illegal Pause Length
000Bxxxxh : Short Length Error
000Cxxxxh : Illegal Parameter
000Dxxxxh : Illegal ZERO
000Exxxxh : Pre-gap Generation Error
000Fxxxxh : Subcode Q-ch Generation Error
0010xxxxh : Not Enough Memory

 xxxxh : Cue Sheet Line Number (1 line: 8bytes)

***** End of Document *****